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Draft Remedial Investigation/Feasibility Study Work Plan for the 1100-EM-1 Operable Unit Hanford Site, Richland, Washington

Environmental Engineering Group

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ACRONYMS AND ABBREVIATIONS

AA	atomic absorption
ABN	acid-base neutral
ADI	aceptable daily intakes
Agreement	consent order and compliance agreement between the EPA, DOE, and Ecology
AIC	acceptable intake for chronic exposure
AIS	acceptable intake for subchronic exposure
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
BDCM	bromodichloromethane
BHC	benzene hexachloride
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	contract laboratory program
CpF	carcinogenic potency factor
CRQL	contract-required quantitation limits
DMS	data management system
DOE	U.S. Department of Energy
DQO	data quality objective
ECD	electron capture detector
Ecology	Washington Department of Ecology
ECTS	Environmental Compliance Tracking System
EIS	Environmental Impact Statement
EP	extraction procedure
EPA	U.S. Environmental Protection Agency
FID	flame ionization detector
FS	feasibility study
GC	gas chromatography
GFAA	graphite furnace atomic absorption
HASP	health and safety plan
HECR	Hanford Environmental Compliance Report
HEHF	Hanford Environmental Health Foundation
HEIS	Hanford Environmental Information System
HISS	Hanford inactive site survey
ICP	inductively coupled plasma
IRA	interim remedial action
LEL	lower explosive limit
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCS	management control system

MS	mass spectroscopy
M-xyle	meta xylene
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NPL	National Priorities List
NR	not regulated (in groundwater)
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
p/b	parts per billion
p/m	parts per million
PCB	polychlorinated biphenyl
PCE	perchloroethene
PDMS	Programmable Data and Management System
PJSP	pre-job safety plan
PMP	project management plan
PNL	Pacific Northwest Laboratory
QA	quality assurance
QC	quality control
RA	remedial action
RCR	review comment record
RCRA	Resource Conservation and Recovery Act
RDR	remedial design report
RI	remedial investigation
ROD	record of decision
SAP	sample and analysis plan
SARA	Superfund Amendment and Reauthorization Act
SMCL	secondary maximum contaminant level
SSO	site safety officer
TC	trichloroacetic acid
TCE	trichloroethylene
TOC	total organic carbon
TOX	total organic halogen
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
VOC	volatile organic compound
WAC	Washington Administrative Code
Westinghouse Hanford	Westinghouse Hanford Company
WIDS	Waste Information Data System

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This work plan was initiated and prepared in accordance with U.S. Environmental Protection Agency (EPA) guidance as stated in Guidance on Remedial Investigations Under CERCLA (EPA 1985d) and Guidance on Feasibility Studies Under CERCLA (EPA 1985c). It provides a description of the tasks required to complete the remedial investigation and feasibility study (RI/FS), which will identify appropriate remedial actions (RA) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendment and Reauthorization Act of 1986 (SARA). Tables 1-1 and 1-2 provide a general outline for RI/FS work plans that is consistent with more recent regulatory guidance (EPA 1988a). The tables indicate the section of this work plan where the information indicated can be obtained. This work plan is intended to address investigation and remediation of inactive waste sites within the 1100-EM-1 operable unit in the proposed 1100 National Priorities List (NPL) Aggregate Area. Additional RI/FS work plans will be prepared to address other operable units.

Table 1-1. Generic Outline for Remedial Investigation and Feasibility Study Work Plans With Corresponding Section in 1100-EM-1 Work Plan Indicated.

Outline[a]	Location in this document
Introduction	Section 1.0
Site background and setting	Sections 2.0, 4.1, and Appendix A
Initial evaluation	Section 4.4 and Appendix B
Work plan rationale	Section 4.3
Remedial investigation/feasibility study tasks	Section 7.0
Costs and key assumptions	Section 7.2
Schedule	Section 3.5
Project management	Section 3.0
References	Section 10.0

[a]EPA 1988a.

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This work plan also conforms, in part, with the Council on Environmental Quality (CEQ) requirements (CEQ 1978) promulgated under the National Environmental Policy Act of 1970 (NEPA). This work plan, the results of work performed pursuant to it, and subsequent RA decisions will be circulated for public and Federal and State agency review to satisfy CEQ procedural requirements. This work plan is based on the assumption that complete conformance with CEQ requirements will be achieved through the development of a supplemental, programmatic environmental impact statement (EIS). The programmatic EIS, which will encompass all CERCLA activities on the Hanford Site, will address those environmental factors that are not normally relevant to an

RI/FS. Such factors include assessing cumulative impacts, impacts on energy and natural resources, transportation, and public services and utilities for the Hanford Site.

Table 1-2. Generic Outline for Remedial Investigation and Feasibility Study Quality Assurance Plan and Sampling and Analysis Plan With Corresponding Section in 1100-EM-1 Work Plan Indicated.

Outline[a]	Location in this document
Sampling and Analysis Plan	
Site background	Section 4.1
Sampling objectives	Section 4.2
Sample location and frequency	Section 4.4
Sample designation	Section 4.4
Sampling equipment and procedures	Section 4.4
Sample handling and analysis	Section 4.4
Quality Assurance Plan	
Project description	Section 5.2
Project organization and responsibilities	Section 5.2
Quality assurance objectives for measurement	Section 5.3
Sampling procedures	Section 5.4
Sample custody	Section 5.4.2
Calibration procedures	Section 5.5
Analytical procedures	Contract Laboratory Program statements of work[b]
Data reduction, validation, and reporting	Section 5.7
Internal quality control	Sections 5.6 and 5.8
Performance and systems audits	Section 5.8
Preventive maintenance	Section 5.5
Data assessment procedures	Section 5.7
Corrective actions	Section 5.8.4
Quality assurance reports	Section 5.8.3

[a]EPA (1988a).
[b]EPA (1988d, 1989).

PST89-3024-2

In addition to the programmatic EIS, the NEPA process will be applied for each individual operable unit before the initiation of RI work to ensure that potential impacts to workers, the public, and the environment are mitigated while gathering data. Similarly, based on the data gathered during RI, a NEPA review will be completed for the proposed remedial action identified in the Phase 3 FS.

The primary focus of this work plan is on the initial phase of the RI. Because of the nature of the RI/FS process, the work plan is anticipated to be revised as required to reflect an improved understanding of site conditions and waste characteristics obtained as the RI progresses and to accommodate data needs identified during the FS.

1.2 BACKGROUND

Over 1,400 waste sites have been identified on the Hanford Site. These include active treatment, storage, and disposal (TSD) facilities, subject to permit application and/or closure under the Resource Conservation and Recovery Act of 1976 (RCRA) and the Dangerous Waste Regulations, Washington Administrative Code (WAC) 173-303 (Ecology 1987a), as well as inactive waste sites subject to corrective action under RCRA or RA under CERCLA. Most of these sites are located within four geographic areas on the Hanford Site that are referred to as the 100, 200, 300, and 1100 Aggregate Areas. Figure 1-1 shows the location of these areas. Each area is subdivided into operable units on the basis of waste disposal practices, geology, hydrogeology, and other pertinent site characteristics. To date, 74 operable units have been identified. Individual sites within each operable unit may be reclassified as information is gathered on each site. A listing of operable units and a description of how individual waste sites are organized into operable units are contained in an operable units report (WHC 1989b).

The 1100 Area is the location of vehicle maintenance operations and warehouse facilities that support activities at the Hanford Site. Little specific information is available regarding past waste disposal practices in the 1100 Area. The 1100 Area is located approximately 0.5 mi west of the north Richland well field, which constitutes a significant source of drinking water for the city of Richland. The potential threat to public water supplies is considered the primary justification for NPL inclusion of the 1100 Aggregate Area.

The 1100 Aggregate Area is subdivided into three operable units. These are designated as Liquid Disposal (1100-EM-1), Active Maintenance (1100-EM-2), and Hazardous Waste Staging (1100-EM-3). Figure 1-2 shows the location of various 1100 Area waste sites. Both 1100-EM-2 and 1100-EM-3 appear to have released relatively little or no hazardous material to the environment and are assigned a low priority. However, the 1100-EM-1 operable unit may have received significant volumes of battery acid, paint and paint thinner, antifreeze, hydraulic fluids, waste oils, and various solvents. Therefore, it has been assigned a relatively high priority because of the proximity to public water supply wells.

1.3 OVERVIEW OF THE REMEDIAL INVESTIGATION AND FEASIBILITY STUDY PROCESS

The Hanford Federal Facility Agreement and Consent Order (Ecology et al. 1989) between the Washington Department of Ecology (Ecology), the EPA, and the U.S. Department of Energy (DOE) has recently been completed (hereafter

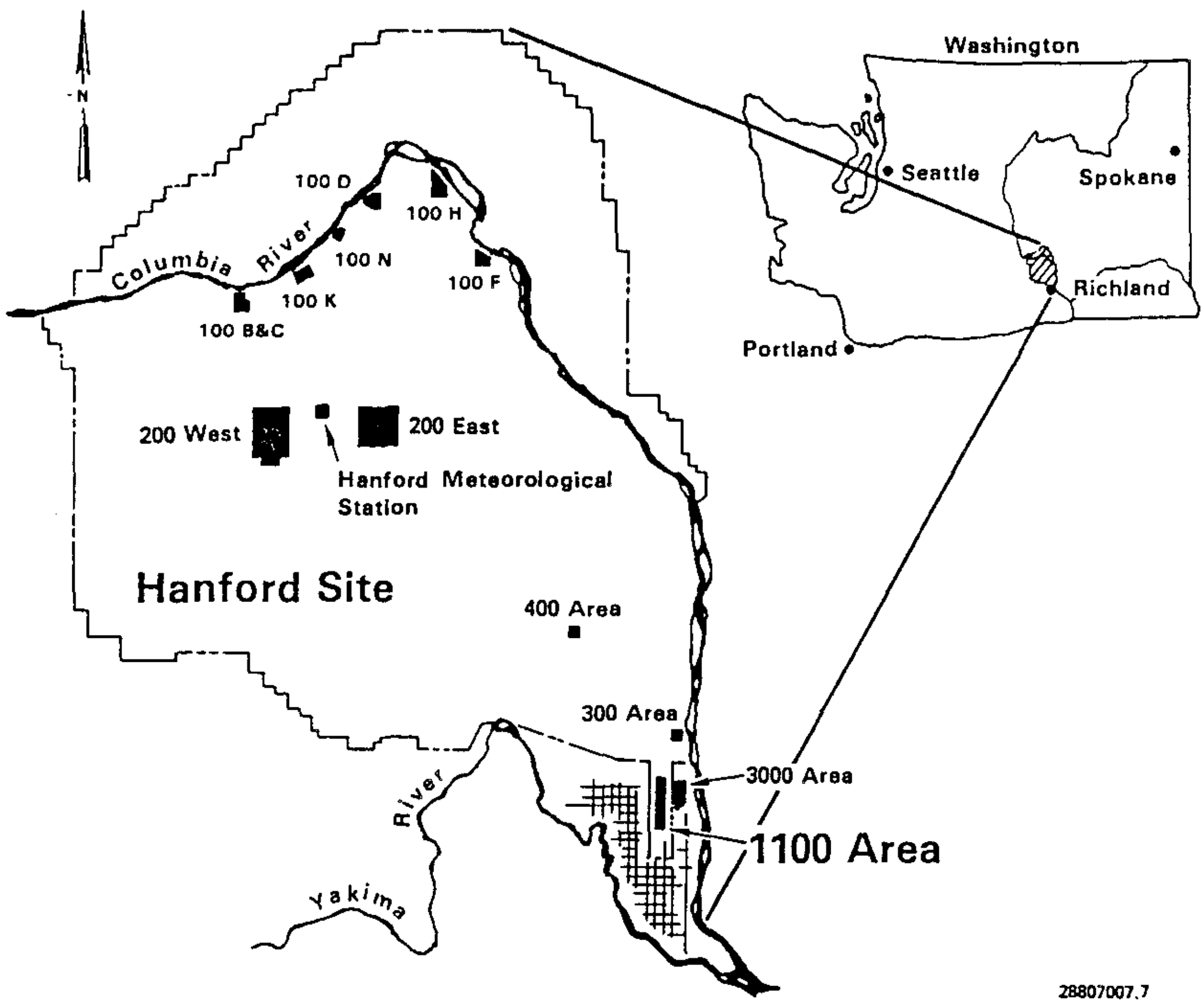

Figure 1-1. Hanford Site Map.

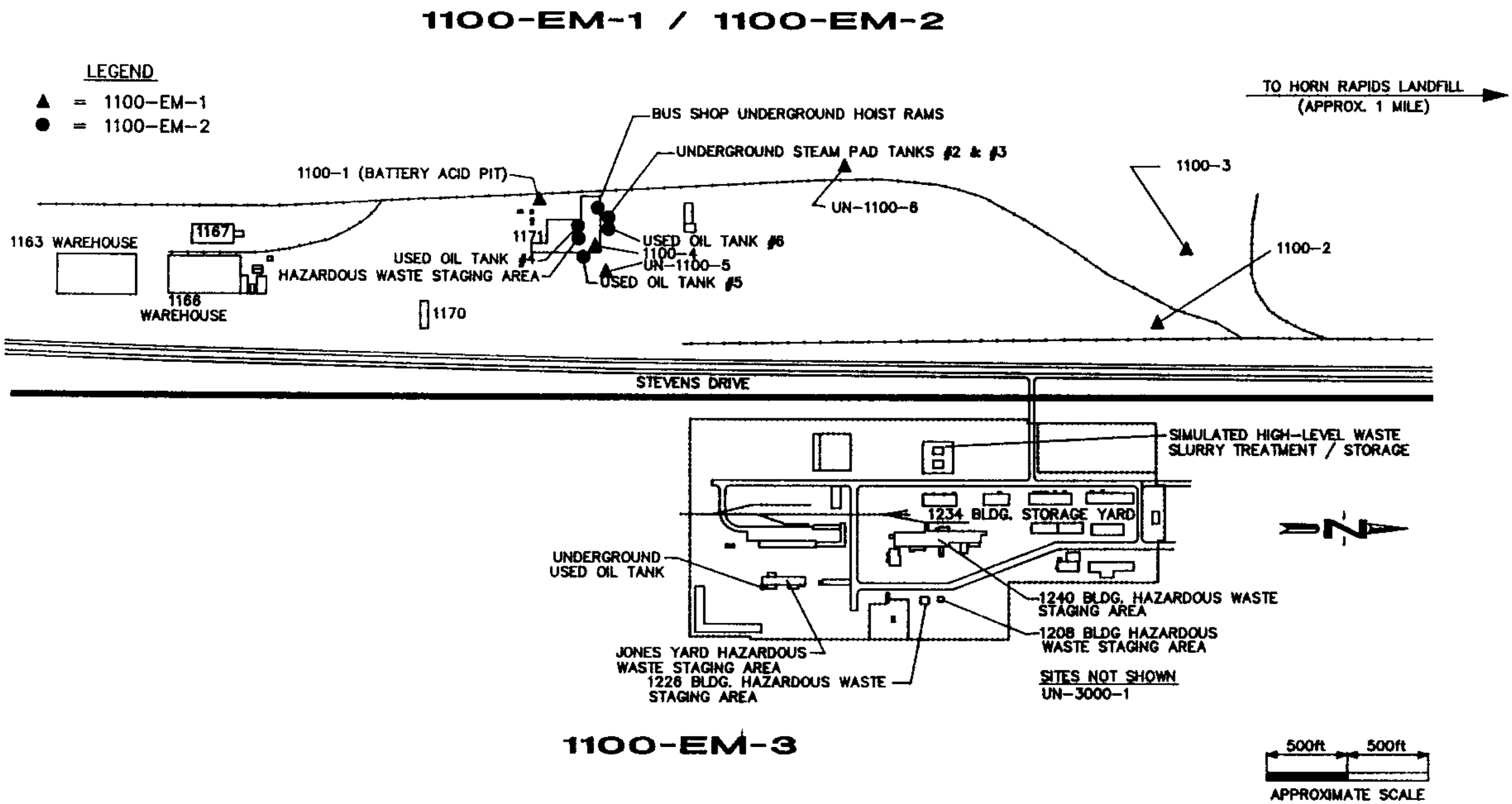

Figure 1-2. 1100 Area Operable Units.

referred to as "the Agreement"). This work plan discusses how the investigation and remediation of the 1100-EM-1 waste sites will be conducted under CERCLA and the terms of the Agreement, as set forth in Section 7.0 of the "Proposed Action Pan for Implementation of the Hanford Federal Facility Agreement and Consent Order" (hereafter referred to as "the Action Plan").

The ultimate goal of the CERCLA program at the Hanford Site is to select and implement a cost-effective remedial alternative that mitigates threats to, and provides protection of, public health, welfare, and the environment, consistent with regulatory requirements and guidelines established by the EPA, Ecology, and DOE.

After a waste site has been listed on the NPL, an RI/FS is carried out to determine the nature and extent of the threat posed by hazardous substances, to identify and screen proposed remedial alternatives, and to evaluate appropriate remedial alternatives on the basis of effectiveness, ability to implement, and cost. After public review and comment, EPA, with input from Ecology, will select an appropriate remedy and document this choice in a record of decision. Figure 1-3 indicates the overall RI/FS process. Important data and findings to support the record of decision will be included in primary documents subject to agency and public review. For individual waste sites where no remedial action appears to be warranted, the basis for this recommendation will be documented in the FS Phase 1 and 2 Report or the FS Phase 3 Report.

Primary objectives of the RI are to collect onsite data and waste characteristics, assess contaminant pathways and transport mechanisms, and conduct treatability testing as necessary to support the evaluation of proposed remedies. The FS identifies, screens, and evaluates potential remedial alternatives. Data are collected during the RI to support the development of remedial alternatives in the FS, which in turn affects the data needs and scope of subsequent investigations. The RI and the FS are conducted concurrently in several phases. Data collected in the initial phase of the RI are used to develop a general understanding of the site, improve the conceptual model derived from existing data, and provide a preliminary assessment of the nature and extent of any contamination. The initial phase of the FS identifies potential RA and determines the threat to public health and the level of risk associated with no action. Subsequent phases of the RI will satisfy specific data needs identified in the FS. Later phases of the FS will include screening of remedial alternatives and feasibility-level design and cost estimates for appropriate remedial alternatives.

Particularly where groundwater is involved, contamination observed in the vicinity of the 1100 Area may or may not be a result of waste disposal activities associated with the individual waste sites identified as part of the 1100-EM-1 operable unit. Other potential sources of groundwater contamination both within and outside the Hanford Site are known to exist in the vicinity of the 1100 Area. The RI/FS is not intended to investigate these sources specifically. However, the extent to which they contribute contaminants to the groundwater in the 1100 Area will be investigated if necessary.

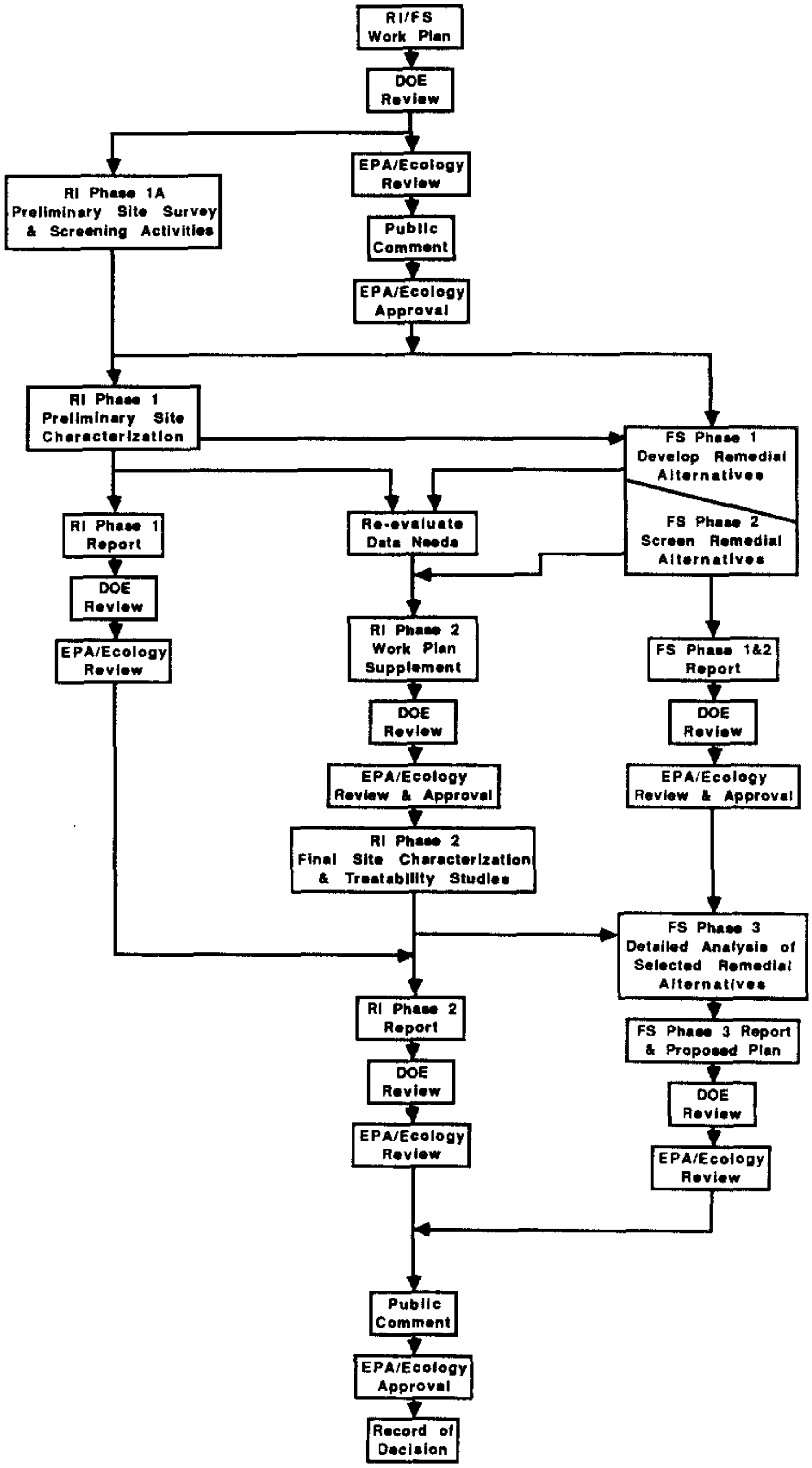

Figure 1-3. Remedial Investigation/Feasibility Study Process for the 1100-EM-1 Operable Unit.

1.4 WORK PLAN ORGANIZATION

This RI/FS work plan contains seven interrelated plans. These are as follows:

- Project management plan
- Sampling and analysis plan
- Quality assurance plan
- Health and safety plan
- Technology plan
- Data management plan
- Community relations plan.

These plans are included as sections within the work plan as follows:

- Section 2.0 provides a brief description of site conditions and waste disposal at each of the individual waste sites in the 1100 Area.
- Section 3.0 discusses the project management plan. This defines organizational relationships and responsibilities, reporting requirements, and financial and project tracking requirements and presents work plan schedules.
- Section 4.0 discusses the sampling and analysis plan for the 1100 Area. This section also includes a detailed discussion of site background material and describes a conceptual model of contaminant transport mechanisms. The plan defines sampling objectives, data needs, and data quality objectives and provides a description of the sampling and analysis program for each site. The plan provides guidance for the conduct for all field work, coordinates all field activities, and serves as a basis for estimating costs.
- Section 5.0 describes the quality assurance plan, which will ensure that appropriate data of sufficient quality are obtained, that all activities, findings, and results are based on approved, applicable procedures, that all results and analyses are valid and traceable, and that sufficient levels of accuracy, precision, and comparability exist for the data.
- Section 6.0 is the health and safety plan, which describes the policies and procedures that will be implemented to protect workers and the public from potential hazards associated with remedial investigation activities.

- Section 7.0 is the technology plan. This section discusses remedial response objectives, presents criteria for development and screening of remedial alternatives, and outlines the methodology for evaluation of remedial alternatives.

- Section 8.0 discusses the data management plan, which outlines the approach used to ensure that all data generated during the RI/FS are handled and reported in a consistent, traceable, and controlled manner.

- Section 9.0 discusses the community relations plan that will be implemented to provide an established formal means of addressing community concerns and establishing a dialogue between the public and the agencies and contractors involved in the RI/FS.

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2.0 SITE DESCRIPTION

The 1100 Area has been used as a maintenance area, warehouse facility, and equipment storage yard in support of operations at the Hanford Site. The 1100 Area is located near the southeastern corner of the Hanford Site (see Figure 1-1). This includes the eastern half of Section 27, the eastern half of Section 22, and the southeast quarter of Section 15, township 10 north, range 27 east, Willamette Standard Meridian. The Horn Rapids landfill, which occupies the northern half of Section 15, has also been included in the 1100 Area. For remediation purposes, the 3000 Area, which lies east of Stevens Drive, is also considered as part of the 1100 Area.

For purposes of this investigation, the use of the subject disposal sites is assumed to have been continuous for approximately 30 yr. The types of potentially hazardous waste disposed of at these sites include battery acid, paint, paint thinner, solvents, hydraulic oils, degreasers, and anti-freeze. Only limited information regarding disposal practices and site conditions is currently available.

The 1100-EM-1 operable unit includes an abandoned battery acid pit (dry well), two abandoned gravel pits used for waste disposal, the site of a leaking antifreeze tank (since removed), the site of a minor radiation contamination incident, and the Horn Rapids landfill. Note that "Horn Rapids landfill" refers to an abandoned dump site on the southern boundary of the Hanford Site, not the active landfill operated by the city of Richland. Table 2-1 lists individual waste sites and known or suspected contaminants at each site. Figure 2-1 shows the location of each site.

The following is a summary of regional and local conditions relevant to the RI/FS. More detailed information relevant to this 1100 Area operable unit can be found in Appendix A.

The 1100 Area lies on an elongated north-south plateau at an elevation of approximately 400 ft above sea level. The land surface slopes generally to the southwest toward the Yakima River and to the east toward the Columbia River. The area is characterized by southwest-trending sand dunes with low to moderate relief. The dunes are up to 10 ft thick and are largely stabilized by vegetation or have been reworked by grading and excavation for plant facilities.

Surficial deposits consist primarily of eolian sands and silts. These form a veneer of varying thicknesses over the Pasco Gravels and Ringold Formation, which consist primarily of gravel, gravelly sand, sand, and silty sand. The contact between the Pasco Gravels and the Ringold Formation occurs at a depth of approximately 50 ft below ground surface. Occasional interbeds of clay and siltstone occur within the Ringold Formation. Basalts of the Columbia River Basalt Group are present below a depth of approximately 160 to 200 ft below ground surface.

Table 2-1. 1100-EM-1 Operable Unit Waste Sites.

Site identifier	Site name	Service dates	Probable contaminants
1100-1	Battery acid pit	1954 - 1977	Sulfuric acid, lead compounds
1100-2	"Paint and solvent pit"	1954 - 1985	Paint thinners, solvents, paints
1100-3	"Antifreeze and degreaser pit"	1979 - 1985	Ethylene glycol, degreasing solvents, wash water from vehicle and equipment cleaning
1100-4	Antifreeze tank site	Pre-1978	Ethylene glycol
UN-1100-5	Radiation contamination incident	August 24, 1962	Leak of radioactive water onto truck bed, possible ground contamination
Unnumbered	Horn Rapids disposal	Pre-1970	Office and construction wastes, septic tank waste, sewage sludge, fly ash, asbestos materials, carbon tetrachloride, other solvents, paints, etc.
UN-1100-6	"Discolored - soil" site	Unknown	Surface spill: possible synthetic organic compounds

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Groundwater occurs in confined aquifers within the basalt sequence, and in the unconfined aquifer of the Pasco gravels and Ringold Formation. The unconfined aquifer in the area exhibits relatively high permeability, particularly in the Pasco gravels. Hydrostratigraphic units are subject to lateral variation. Perched or semiperched water conditions may also occur locally. The estimated depth to the water table in the vicinity of the 1100 Area is approximately 50 ft. The boundary between the confined and unconfined aquifers is generally the lowermost silt and clay member of the Ringold Formation.

The regional groundwater flow direction is from west to east. However, there are local perturbations, and the water table in the area of interest is not known in sufficient detail to predict groundwater flow directions at any particular point. Moreover, the direction and velocity of groundwater flow is likely to be time-variant, particularly in the vicinity of pumped wells and/or recharge areas.

Available data suggest that infiltration or gaseous diffusion of contaminants through the soil column to the unconfined aquifer is the most credible pathway for contaminant transport to potential receptors. The city of Richland operates recharge ponds and shallow wells tapping the unconfined aquifer in the north Richland well field, which is located approximately 0.5 mi east of the 1100 Area. Therefore, the possibility of groundwater contamination is the primary concern in the 1100 Area.

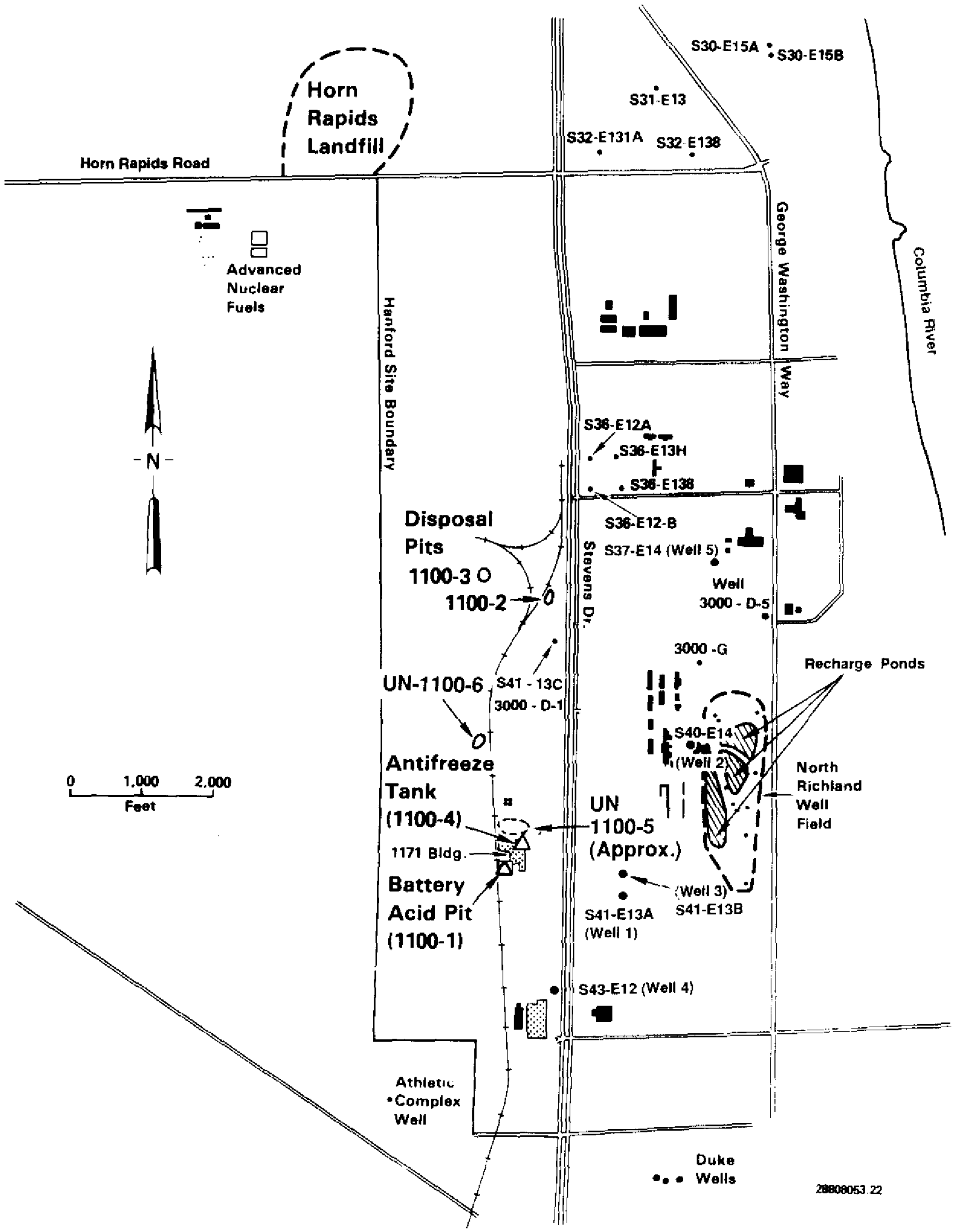

Figure 2-1. Waste Site Locations for the 1100-EM-1 Operable Unit.

On an annual basis, precipitation is less than evaporation. However, localized recharge may occur during the winter and early spring. No permanent or ephemeral streams exit in the vicinity of the sites. Furthermore, the surface characteristics and infiltration capacity of the soil at each site do not lend themselves to dispersal of contaminants directly to surface water via an overland route.

Volatilization or air entrainment of contaminants is not considered likely unless the sites are disturbed. Spread of contamination by direct contact is also considered to be unlikely.

3.0 PROJECT MANAGEMENT PLAN

3.1 INTRODUCTION

The purpose of this project management plan (PMP) is to define the administrative and institutional tasks necessary to support RI/FS activities in the 1100-EM-1 operable unit at the Hanford Site under CERCLA. This plan defines the responsibilities of the various participants, the organizational structure, and the project tracking and reporting procedures. This PMP is in accordance with the provisions of the action plan. Revisions to the action plan may result in changed requirements that would supersede the provisions of this plan.

3.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

3.2.1 Interface of Regulatory Authorities and the U.S. Department of Energy

The 1100-EM-1 operable unit is defined as a CERCLA past practice (CPP) unit. In accordance with Section 5.6 of the Action Plan, the EPA has been designated as the lead regulatory agency. Accordingly, the EPA is responsible for overseeing remedial activity at this unit and ensuring that the applicable authorities of both the EPA and Ecology are applied. The lead regulatory agency concept is discussed in Section 5.6 of the Action Plan.

The process by which the RI/FS will be conducted is described in Section 7.3 of the Action Plan.

3.2.2 Project Organization and Responsibilities

The top level project organization is shown on Figure 3-1. The following sections describe the responsibilities of the individuals shown on Figure 3-1.

Project Managers. The EPA, DOE, and Ecology will each designate one individual as project manager, who will serve as the primary point of contact for all activities to be carried out under the agreement and action plan. In addition, each of the above three parties will designate an alternate project manager. The primary responsibilities of the project managers are discussed in Section 4.1 of the Action Plan.

Unit Managers. The EPA, DOE, and Ecology will each designate a unit manager for this RI/FS; the unit manager from EPA will serve as the lead unit manager. The responsibilities of the unit managers are discussed in Section 4.2 of the Action Plan.

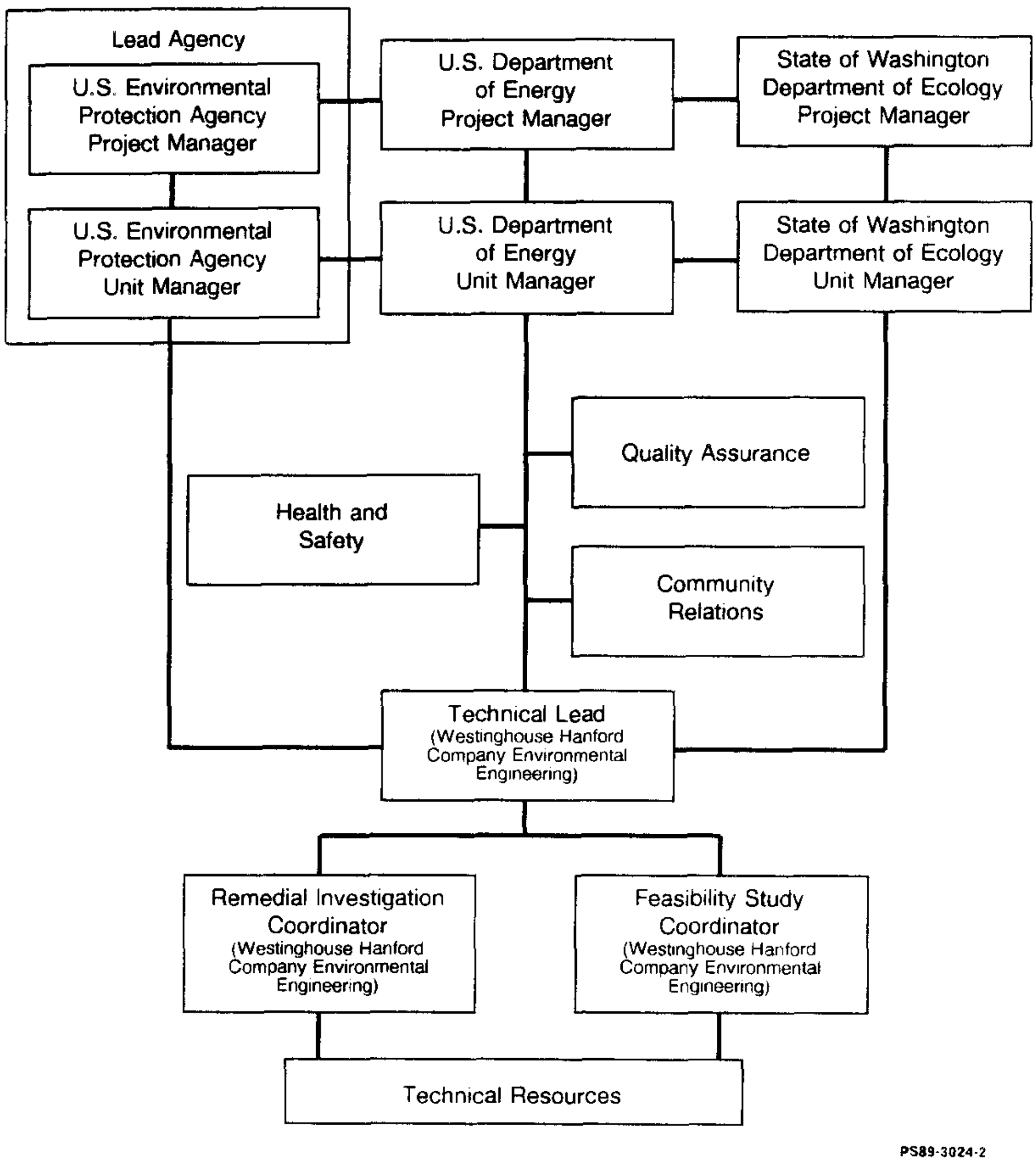

Figure 3-1. Project Organization.

Technical Lead. The technical lead will be a designated person within the Westinghouse Hanford Environmental Engineering Group. The responsibilities of the technical lead will be to plan, authorize, and control work so that it can be completed on schedule and within budget, and to ensure that all planning and work performance activities are technically sound.

Remedial Investigation Coordinator. The RI coordinator will be responsible for coordinating all activities related to Phases 1 and 2 of the RI, including data collection, analysis, and reporting. The RI coordinator will be from the Westinghouse Hanford Environmental Engineering Group, and will be responsible for keeping the technical lead informed on the RI work status and any problems that may arise.

Feasibility Study Coordinator. The FS coordinator will be responsible for coordinating all activities related to Phases 1, 2, and 3 of the FS, including data collection, analysis, and reporting. The FS coordinator will be from the Westinghouse Hanford Environmental Engineering Group, and will be responsible for keeping the technical lead informed on the FS work status and any problems that may arise.

Remedial Investigation Technical Resources. The various technical resources responsible for performing the RI are shown on Figure 3-2. These resources will be responsible for performing data collection, analysis, and reporting for the technical activities related to the RI. Figures 3-3 through 3-7 show detailed organizational structure for specific RI tasks.

Internal and external work orders and subcontractor task orders will be written by the RI coordinator to use these technical resources, which are under the control of the technical lead. Statements of work will be provided that will include a discussion of authority and responsibility, a schedule with clearly defined milestones, and a task description including specific requirements. Each group will keep the RI coordinator informed on the RI work status performed by that group and of any problems that may arise.

Feasibility Study Technical Resources. The various technical resources responsible for performing the FS are shown on Figure 3-2. These resources will be responsible for identifying and screening remedial alterations, and for detailed evaluation of selected alternatives.

Internal and external work orders and subcontractor task orders will be written by the FS coordinator to use these technical resources, which are under the control of the technical lead. Statements of work will be provided that will include a discussion of authority and responsibility, a schedule with clearly defined milestones, and a task description including specific requirements. Each group will keep the FS coordinator informed on the FS work status performed by that group and of any problems that may arise.

Figure 3-2. Technical Resources for Conducting Remedial Investigations/Feasibility Studies.

Technical Resources		
Subject/Activity	**Remedial Investigation**	**Feasibility Study**
Hydrogeology and geology	Westinghouse Hanford[a]/Geosciences PNL[b]/Earth and Environmental Sciences Center	Westinghouse Hanford/ Geosciences
Toxicology and risk/ endangerment assessment	Westinghouse Hanford/ Environmental Technology PNL/Earth and Environmental Sciences Center PNL/Life Sciences Center	Westinghouse Hanford/ Environmental Technology
Environmental chemistry	Westinghouse Hanford/Geosciences PNL/Earth and Environmental Sciences Center	Westinghouse Hanford/ Geosciences
Geophysics and field testing	Westinghouse Hanford/Geosciences (Planning) Environmental Field Services	N/A
Geotechnical and civil engineering	N/A	Westinghouse Hanford/ Environmental Engineering and PNL/Waste Technology Center
Groundwater treatment engineering	N/A	Westinghouse Hanford/ Environmental Engineering and PNL/Waste Technology Center
Waste stabilization and treatment	N/A	Westinghouse Hanford/ Environmental Engineering and PNL/Waste Technology Center
Surveying	Kaiser Engineers	N/A
Soil and water sampling and analysis	Westinghouse Hanford/Environmental Engineering and Geosciences Environmental Field Services PNL/Earth and Environmental Sciences Center PNL/Materials and Chemical Sciences Center	N/A
Drilling and well installation	Westinghouse Hanford/Geosciences Environmental Field Services Kaiser Engineers	N/A
Radiation monitoring	Westinghouse Hanford/Operational Health Physics	N/A

NOTE: Qualified subcontractors may conduct all or portions of the RI/FS.
[a]Westinghouse Hanford = Westinghouse Hanford Company.
[b]PNL = Pacific Northwest Laboratory.

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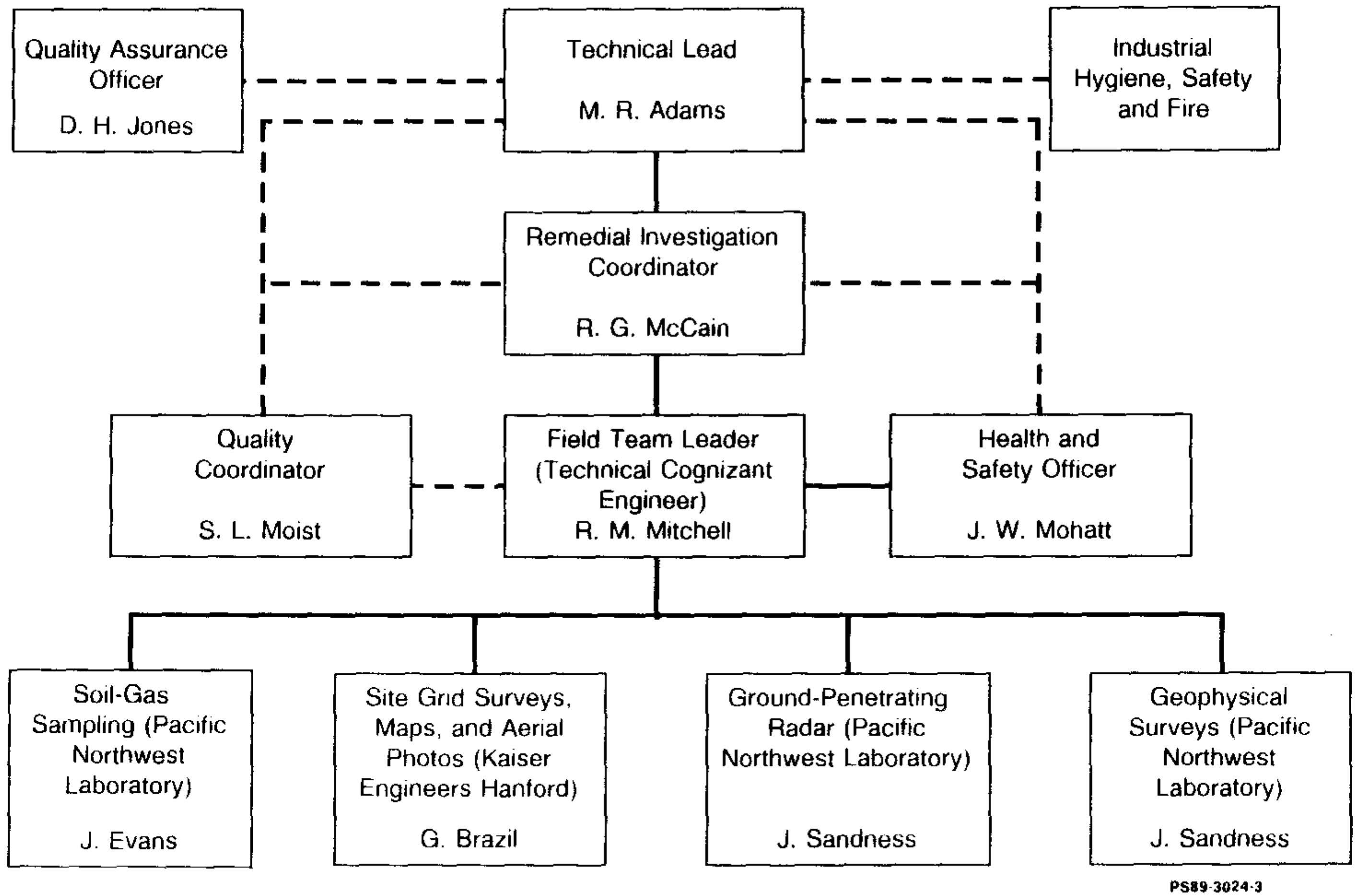

Figure 3-3. 1100-EM-1 Physical and Geophysical Survey Team.

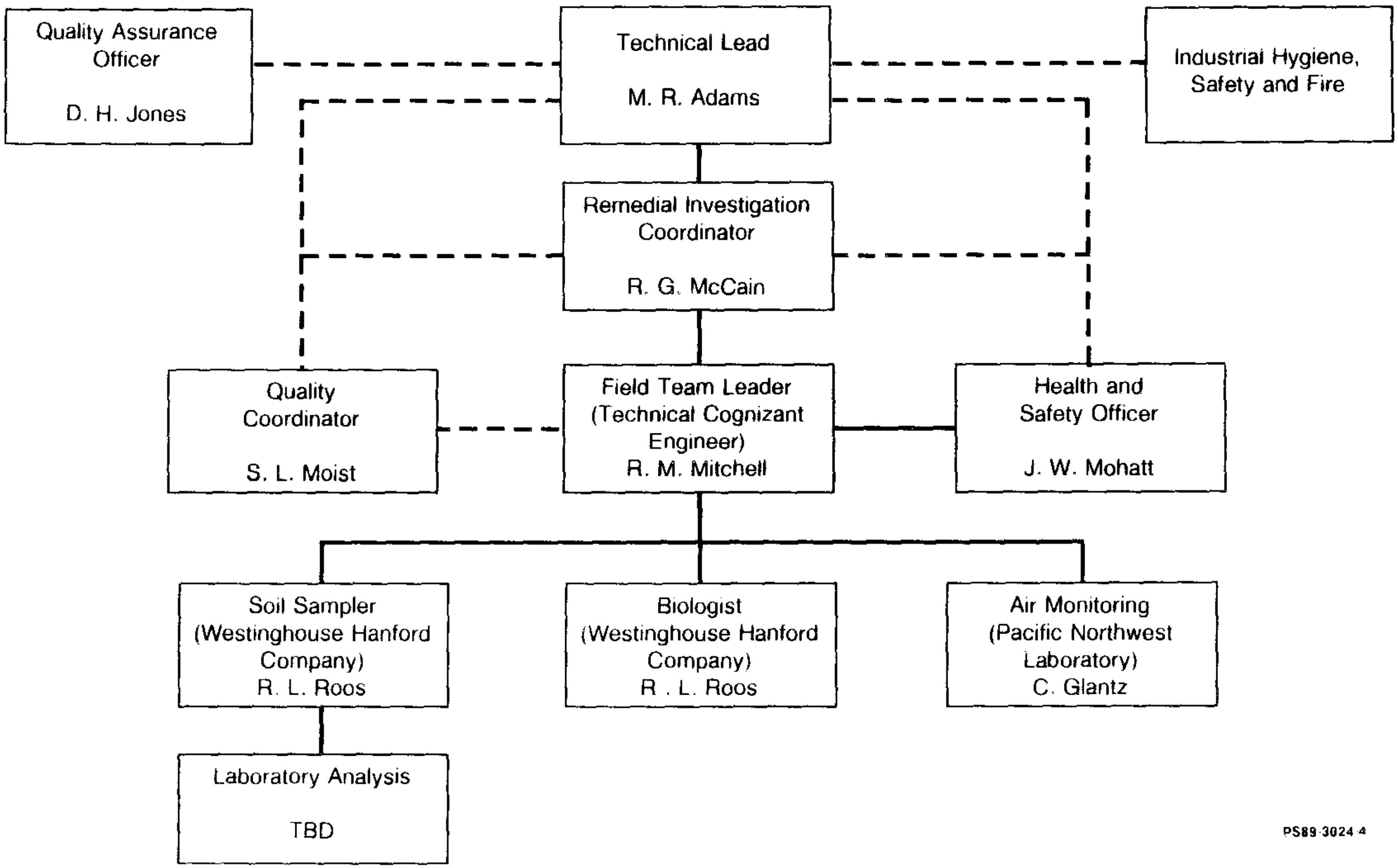

Figure 3-4. 1100-EM-1 Biotic, Air, and Soil-Sampling Team.

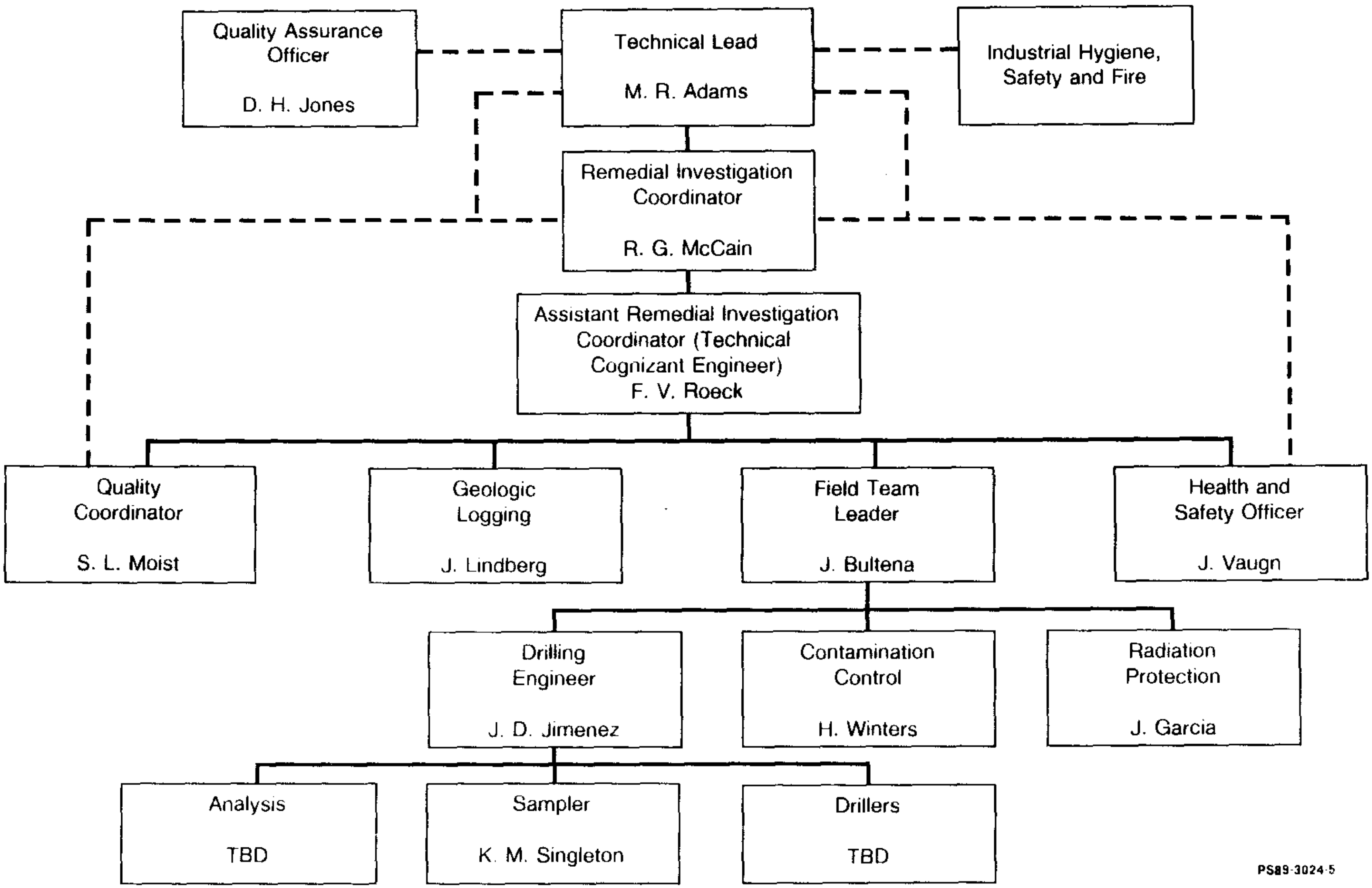

Figure 3-5. 1100-EM-1 Vadose Zone Drilling and Sampling Team #1.

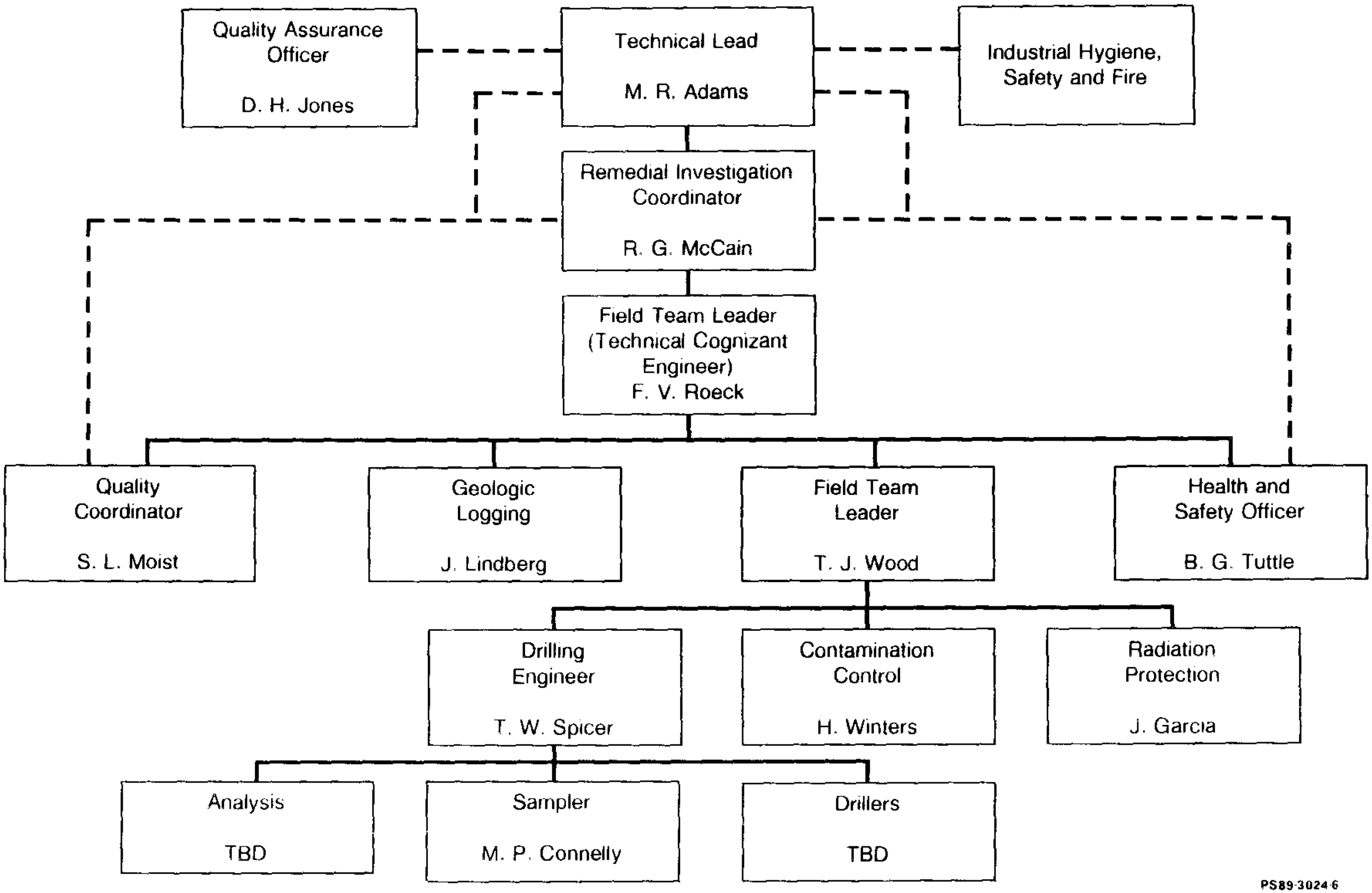

Figure 3-6. 1100-EM-1 Vadose Zone Drilling and Sampling Team #2.

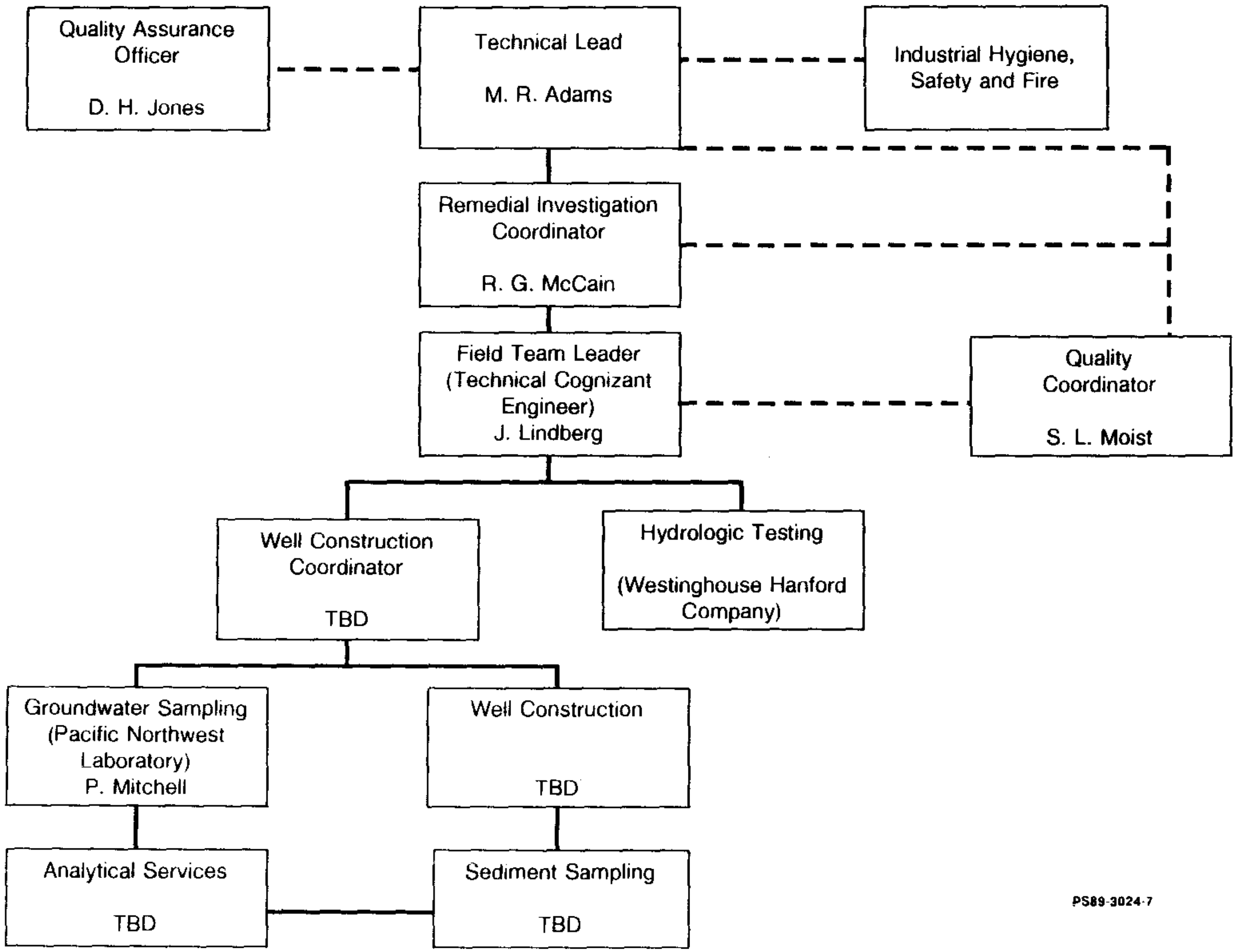

Figure 3-7. 1100-EM-1 Groundwater Well Construction and Hydrologic Testing Team.

3.3 DOCUMENTATION AND RECORDS

3.3.1 Categorization of Documents

As discussed in Section 9 of the Action Plan, all documents will be categorized as either primary or secondary. Primary documents represent the final documentation of key data and reflect the basis for decisions on how to proceed. Primary documents include the following:

- The RI/FS work plan
- The RI Phase 2 report
- The FS Phase 1 and 2 report
- The FS Phase 3 report
- The proposed plan.

Secondary documents represent an interim step in a decision-making process or are issued for information and do not reflect key decisions. Secondary documents include the following:

- The RI Phase 1 report
- Sampling and data results
- Treatability investigation work plan
- Treatability investigation evaluation report
- Supporting studies and analyses
- Other supporting documents, as necessary.

3.3.2 Document Review and Comment

The process for review and comment of both primary and secondary documents is described in Section 9.2 of the Action Plan. Forty-five days are allowed for review by the lead and support regulatory agencies. Although both primary and secondary documents are subject to review, only primary documents require approval by the lead regulatory agency. In the event that comments cannot be resolved, primary documents are subject to the dispute resolution process defined in the Agreement. Comments may be made on all aspects of the document, including completeness, and should include, but are not limited to, technical adequacy and consistency with CERCLA or other pertinent guidance or policy. Where possible, comments should be specific to individual lines, paragraphs, or sections, with adequate specificity so that DOE can respond in detail and make appropriate changes in the document. In cases involving complex or unusually lengthy documents, the EPA may extend the comment period by written notice to DOE.

In commenting on a draft document that contains a proposed applicable or relevant and appropriate requirements (ARAR) determination, the EPA shall include a reasoned statement of whether or not they object to any portion of the proposed ARAR determination. To the extent that the EPA does object, it shall explain the basis for its objection in detail and shall identify any ARARs that it feels were not properly addressed in the proposed ARAR determination.

On secondary documents, EPA and Ecology have the option to provide comments within 45 d of submittal or take no action. If comments are provided, DOE will respond in writing within 30 d.

3.3.3 Revision/Modification of Primary and Secondary Documents

During the course of the work, revision of primary or secondary documents may become necessary to accommodate new information. Modifications are required when they could be of significant assistance in the evaluation of impacts on the public health or environment, evaluation or selection of remedial alternatives, or protection of human health and the environment. The process for revision of primary and secondary documents is discussed in Section 9.3 of the Action Plan.

3.3.4 Administrative Records

An Administrative Record is the body of documents and information that is considered or relied on to arrive at a final decision for remedial action. The requirements governing the Administrative Record for a CERCLA response action are found in Section 113(k) of CERCLA. Executive Order 12580 and CERCLA guidance documents provide that the Administrative Record is to be maintained by DOE at the regulated Federal facility. The procedures by which the Administrative Record will be maintained are discussed in Section 9.4 of the Action Plan. Section 9.4 also provides information regarding the types of documents required to be in the Administrative Record. In general, any correspondence or documents relevant to the evaluation and selection of a remedial alternative will be included in the Administrative Record.

3.3.5 Distribution of Documents and Correspondence

Distribution of documents and correspondence is discussed in Section 9.5 of the Action Plan.

3.3.6 Change Control

Changes to the work plan that impact major milestones in the Action Plan, the work schedule contained in Appendix D of the Action Plan, or supporting schedules require approval. Specific approval authority and the formal change control process are provided in Section 12 of the Action Plan.

Minor field changes are those that have no adverse effect on the technical adequacy of the job or the work schedule. These changes can be made by the person in charge of the particular activity in the field and documented in the daily field log book. If it is anticipated that the field change will affect the work schedule or requires the approval of the lead regulatory agency, the applicable DOE unit manager shall be notified.

3.4 FINANCIAL AND PROJECT TRACKING REQUIREMENTS

3.4.1 Management Control

Westinghouse Hanford will be responsible to plan and control activities and to provide effective technical, cost, and schedule baseline management. The Westinghouse Hanford Management Control System (MCS) will be used for effective planning and control practices. The MCS meets the requirements of DOE Order 4700.1, Project Management System (DOE 1987c), and DOE Order 2250.1B, Cost and Schedule Control Systems Criteria for Contract Performance Measurement (DOE 1985). The primary goals of the Westinghouse Hanford MCS are to provide methods for planning, authorizing, and controlling work so that it can be completed on schedule and within budget and to ensure that all planning and work performance activities are technically sound and in conformance with management and quality requirements.

The work plan schedule and major milestones are described in Section 3.5 of this work plan. The work plan schedule will be the primary vehicle for the unit and technical leads to track progress. The work plan schedule must be consistent with the work schedule contained in the Action Plan.

3.4.2 Meetings and Progress Reports

Monthly unit managers' meetings, quarterly project managers meetings and quarterly progress reports are discussed in Section 8 of the Action Plan.

3.5 WORK PLAN SCHEDULES

The interrelationships between the various elements of the RI/FS are depicted in Figure 1-3. Figure 3-8 shows an integrated schedule for the RI/FS. Both Figure 1-3 and Figure 3-8 have been extensively revised for consistency with the draft Action Plan. These schedules allow time for review and approval of various primary and secondary documents associated with the RI/FS process. These documents constitute the major deliverables for the effort. At this point in the RI/FS process, little is known about actual site conditions and the nature and extent of contamination that will require remediation. For this reason, it is not considered appropriate to provide detailed schedules for later phases of the work, since the work to be accomplished will depend to a large degree on the results obtained during previous phases. More detailed schedules will be developed as information becomes available.

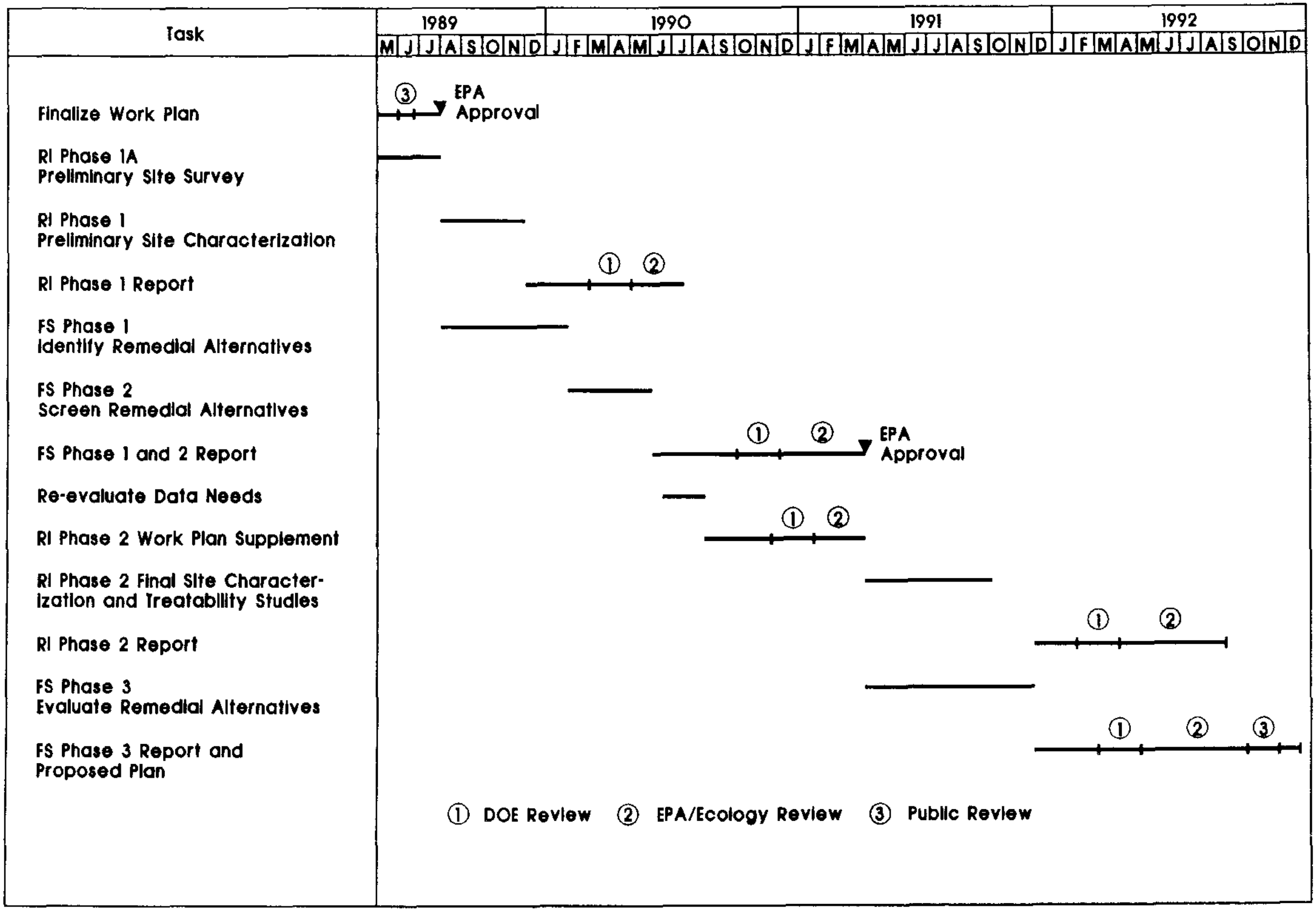

Figure 3-8. Overall Schedule, Hanford Site 1100-EM-1 Operable Unit Remedial Investigation/Feasibility Study.

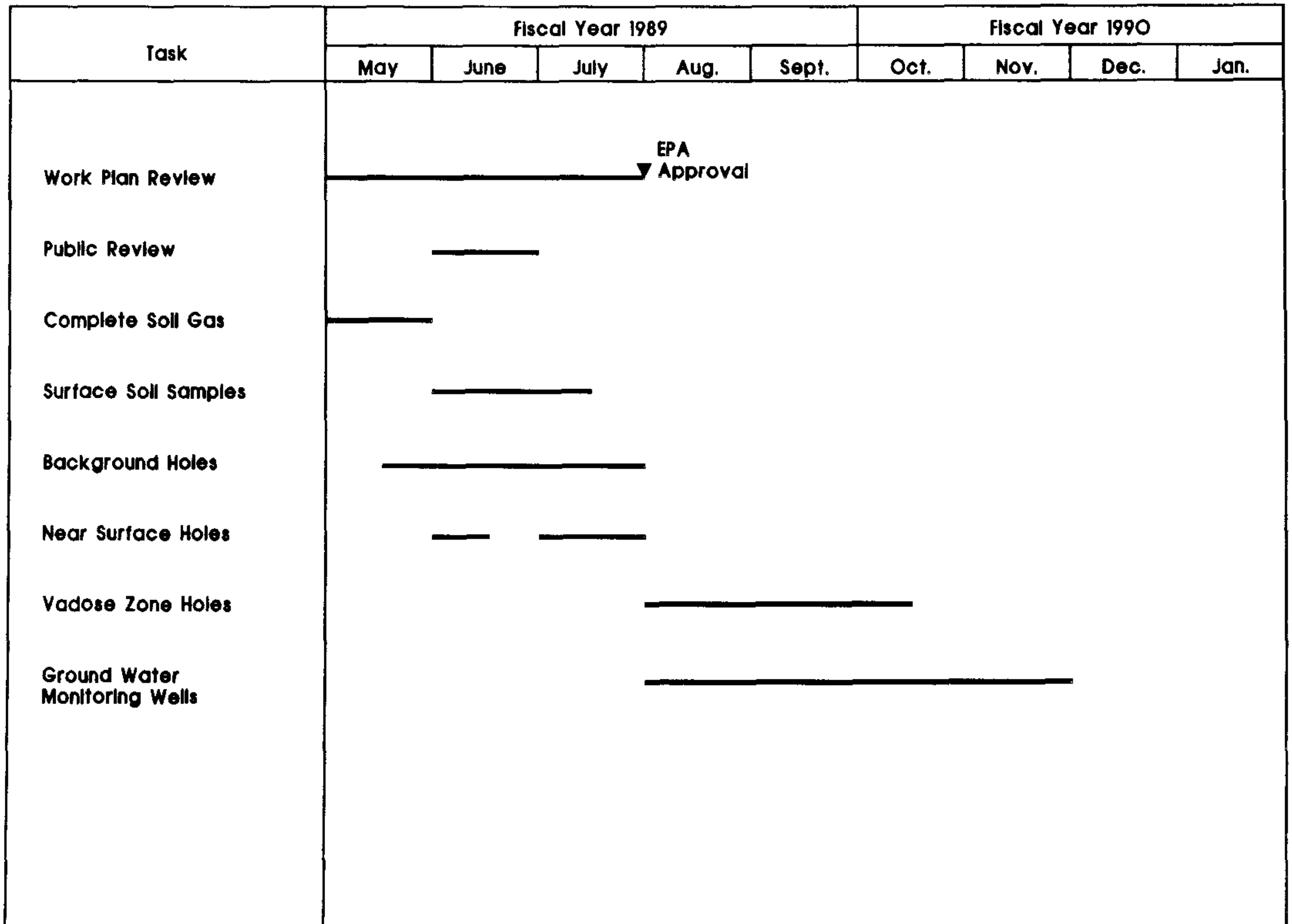

Figure 3-9. Remedial Investigation Phase 1.

A more detailed schedule for the RI Phase 1 is shown in Figure 3-9. This schedule is based on the sampling and analysis program discussed in Section 4.4.

It is anticipated that all schedules will be updated as necessary to reflect changes associated with improved understanding of site conditions and operational experience with RI/FS activities. In particular, developmental work on drilling activities may allow significant compression of the RI schedule for activities requiring drilling.

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4.0 SAMPLING AND ANALYSIS PLAN

The sampling and analysis plan (SAP) defines the level of effort and specific field activities for the RI. The major elements of the SAP are discussed in four sections. Section 4.1 provides a discussion of site background data and presents a conceptual model that identifies potential contaminant sources, pathways, and receptors. Section 4.2 defines sampling objectives for the RI. Section 4.3 identifies data needs and establishes data quality objectives (DQO). Finally, Section 4.4 presents a detailed discussion of the sampling and analysis program for each media of interest at each site.

4.1 SITE BACKGROUND

The 1100 Area includes equipment storage yards, shipping and receiving facilities, and vehicle maintenance facilities for the DOE's Hanford Site. It occupies approximately 1.2 mi^2 at the extreme southeast corner of the Hanford Site, along the northwestern edge of the city of Richland. Figure 1-1 shows the general location of the 1100 Area. For the purposes of this work plan, the Horn Rapids landfill is also included within the 1100 Area operable unit (1100-EM-1).

A summary of the site geology, hydrogeology, meteorology, air quality, and environmental setting is given in Appendix A. Available data from analyses of soil and water samples from the vicinity of the 1100 Area are included in Appendix B.

Limited information is available regarding past waste-disposal practices and site conditions in the 1100 Area. Much of the information obtained to date is based on interviews with motor pool and maintenance department workers. This information has led to the identification of six probable spill or waste disposal locations that may require remedial action under CERCLA/SARA. A seventh possible spill location (UN 1100-6) was identified during area reconnaisance activities. Potential contaminants include spent battery acid, antifreeze, used motor oils and hydraulic oils, solvents, degreasers, paints, paint thinners, and possible radioactive surface contamination.

Approximate locations of each waste site to be investigated are shown on Figure 2-1. Table 2-1 indicates potential contaminants at each site.

The primary environmental concern, with regard to the investigation of the 1100 Area, is the proximity to the city of Richland water supply and other wells. The Duke wells and the north Richland well field (Figure 2-1) supply water to the city of Richland water system. They are within about 0.5 mi of the 1100 Area. The population of Richland (33,578 people, 1980 census) is served by these wells and must be considered as an affected population. Emergency interties also exist to the Kennewick water system and the 300 Area. The Battelle Farms Operations irrigation well, which is completed in the unconfined aquifer, is within a few hundred feet of the 1100 Area east boundary. Other wells that draw water from the unconfined aquifer in the vicinity of the 1100 Area include the Horn Rapids athletic complex, the Lamb-Weston potato processing plant, and various residential irrigation wells in north Richland.

4.1.1 Individual Waste Site Descriptions

The 1100-EM-1 operable unit includes those locations where liquid waste is known (or suspected) to have been disposed to the soil column in the 1100 Area.

Individual waste locations in the 1100-EM-1 operable unit (see Figure 2-1 and Table 2-1) are briefly described below.

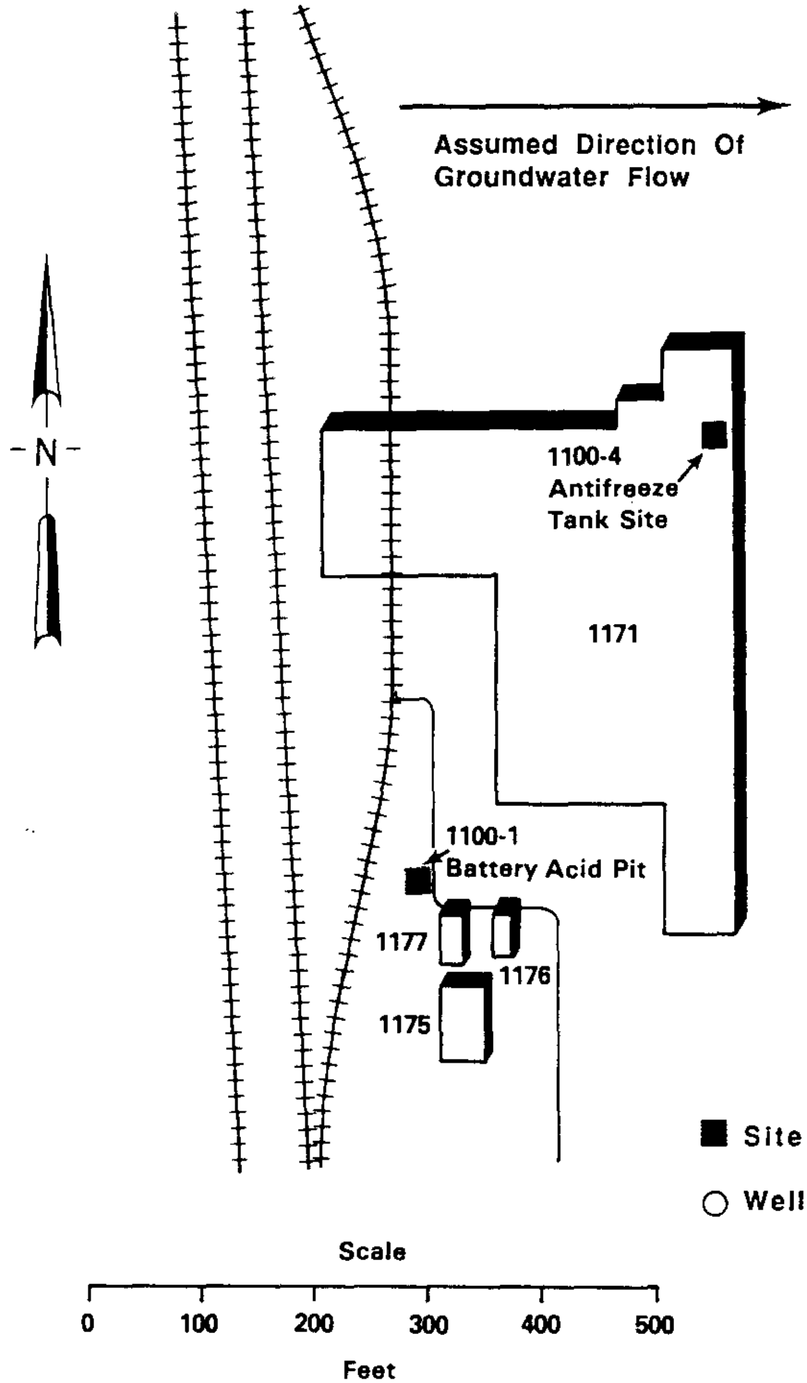
4.1.1.1 Battery Acid Pit (1100-1). During the approximate period of 1954 to 1977, waste battery acid was disposed of into an unlined pit (i.e., dry sump or French drain) with sand and gravel in the bottom. The pit is located a few feet from a paved area, near the southwest corner of the 1171 Building, which is a vehicle service, maintenance, and repair building. Figure 4-1 shows the approximate location of the battery acid pit.

The battery acid pit is located on a very slight slope toward the railroad tracks, which are approximately 50 ft to the west. The exact location and size of the pit is not known, although estimates by motor-pool workers range from 5 to 12 ft in diameter and 5 to 10 ft deep. Based on a review of vehicle fleet size and estimated battery requirements by Hanford Site personnel, the maximum quantity of battery acid disposed of to the pit over a 23-yr period is estimated to be about 15,000 gal. Other liquid materials, such as waste oil, antifreeze, or solvents, may also have been disposed of in the pit, but no record of such disposal exists.

Depth to water table is about 50 ft from ground surface. No chemical inventory is available. Sulfate, lead, and cadmium compounds are the principal anticipated contaminants. Two surface soil samples obtained in March of 1988 were found to contain elevated levels of lead. The results of these analyses are discussed further in Appendix B.

4.1.1.2 "Paint and Solvent Pit" (1100-2). Location 1100-2 was originally developed as a sand and gravel pit. It was used for the disposal of construction debris from 1954 to 1985. The general location of the pit is shown in Figures 2-1 and 4-2. The pit is an elongated depression 4 to 6 ft deep, approximately 250 ft long, and 100 ft wide and lies along the eastern side of the railroad tracks. Depth to the groundwater table is approximately 50 ft from ground surface.

The construction debris is reported to include broken concrete, asphalt, and lumber from construction, maintenance, and demolition activities on the Hanford Site. The pit presently contains approximately 5 ft of backfill material. In addition to construction waste, the pit is reported to have occasionally received waste solvents, paints, and paint thinner. The maximum volume of such disposal is estimated to have been approximately 100 gal/yr. There is no visible evidence of paint, solvent, or discolored soil on the ground surface in the vicinity of this pit. The exact locations of any paint or solvent disposal are unknown. No chemical inventory is available.



Note: Locations shown are approximate

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Figure 4-1. Location of the Battery Acid Pit and Antifreeze Tank Site.

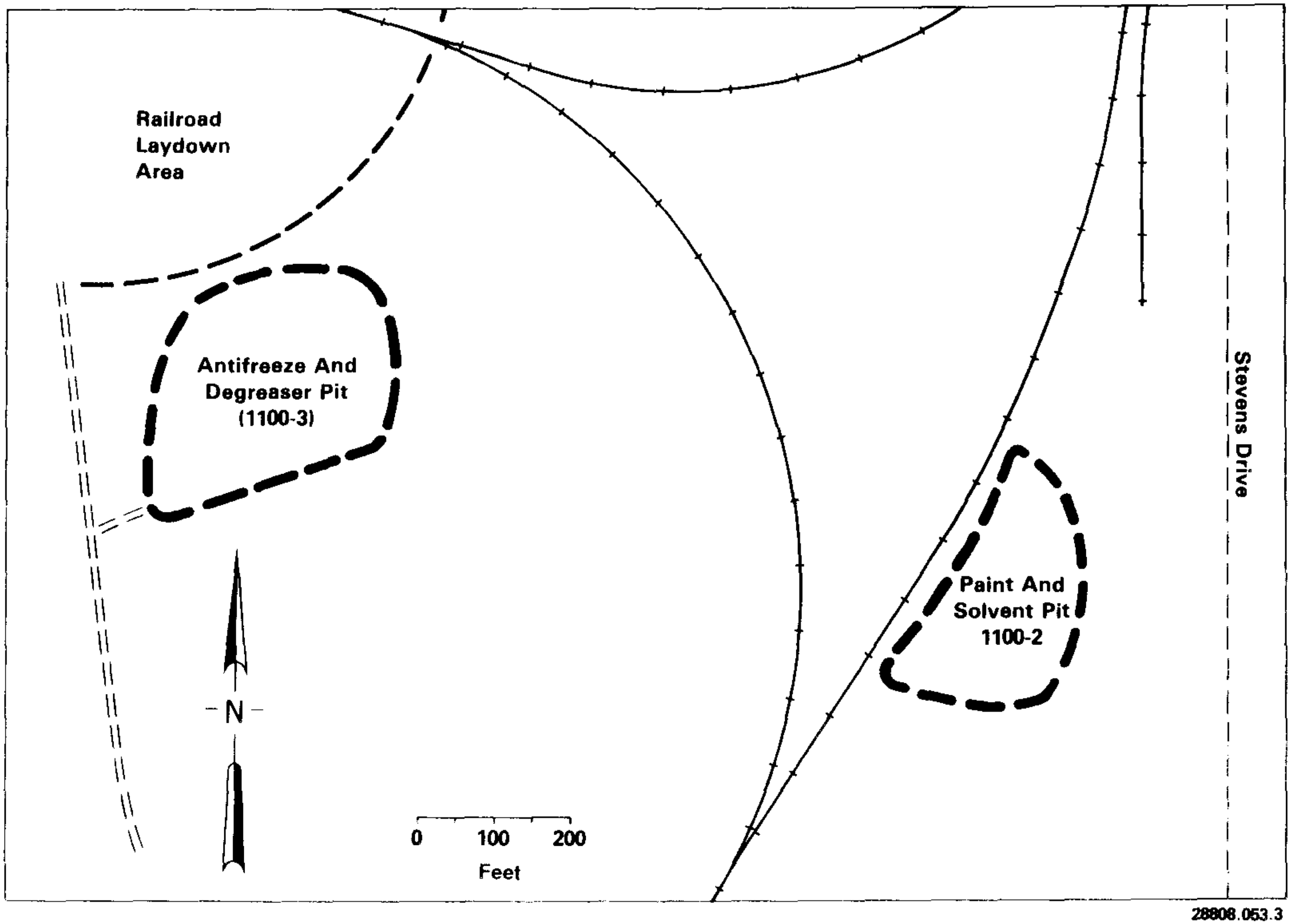

Figure -2. Waste Site Locations.

Analyses of two soil samples collected at the ground surface in March 1988 reveal no evidence of contamination. The analytical results are reported in Appendix B. At present, the only evidence of chemical soil contamination is anecdotal.

4.1.1.3 "Antifreeze and Degreaser Pit" (1100-3). Location 1100-3 is a shallow, roughly circular depression approximately 250 ft in diameter and 6 to 8 ft deep (Figures 2-1 and 4-2). Depth to groundwater is approximately 50 ft. The pit is reported to have been an excavation for sand and gravel, with the bottom of the original pit at roughly the present observed depth. The pit was used for the disposal of construction debris from 1979 to 1985. Approximately 30 yd^3 of used roofing gravel and 1 yd^3 of concrete rubble lie in piles dumped in the bottom of the pit. The pit is also reported to have occasionally received waste antifreeze and degreasing solutions from vehicle cleaning operations at the 1171 Building. The quantities of antifreeze or degreaser disposed of in the pit are unknown, and no specific disposal sites have been identified. There is no visible evidence of such disposal on the ground surface, and analyses of two soil samples taken from the ground surface in March 1988 reveal no evidence of contamination. The analytical results are reported in Appendix B. As with the 1100-2 site, the only evidence of chemical soil contamination is anecdotal.

4.1.1.4 Antifreeze Tank Site (1100-4). This site is the location of a 5,000-gal underground steel tank used for disposal of waste antifreeze in the 1171 Building. In 1986, the tank was emptied, cleaned, and subsequently removed because it was suspected of leaking. No information is available on the amount of antifreeze that may have leaked. During excavation of the tank, three soil samples were collected from soils surrounding the tank. Analysis of these samples did not detect antifreeze (ethylene glycol) in any of the samples.

4.1.1.5 Radiation Contamination Incident (1100-5). On August 24, 1962, radioactive contamination was discovered on an incoming 16-ton shipment cask containing irradiated metal specimens from a facility at the Idaho National Engineering Laboratory. The truck trailer on which the contamination was detected had offloaded other cargo at the 1166 Building and was parked in the "parking lot northwest of the 1171 Building" when the contamination was detected. However, the precise location of the incident with the parking lot is not known.

The radiation incident investigation report indicates that an area approximately 1 ft in diameter on the bed of the trailer was contaminated. Because of concern over leakage from the cask, radiological checks were conducted at several locations including the 1166 Building loading dock, the Pacific Intermountain Express terminal in Pasco, Washington, and a parking lot in Baker, Oregon, where the truck was parked for approximately 8 h. No contamination was detected. The U.S. Atomic Energy Commission officials in Idaho surveyed a location in Twin Falls, Idaho, and found some contamination, which was removed and buried. Available information suggests that significant contamination of the parking lot is highly unlikely and that the area of potential concern is less than 1 ft in diameter. A logical assumption is that Hanford Site radiation monitors carefully checked the ground beneath the trailer; however, the investigation report does not explicitly make such a statement. A recent radiological survey of the parking lot failed to detect any contamination.

4.1.1.6 Horn Rapids Landfill. The Horn Rapids landfill (Figures 2-1 and 4-3) is an inactive disposal site that was used primarily for office and construction waste from the early 1950s to 1970. This is not to be confused with the city of Richland municipal-waste disposal site. Discussions with Hanford Site personnel involved in the operation of the landfill indicate that other wastes are likely present, including possibly as many as 200 drums of carbon tetrachloride. Mention is made of standing water and "springs," which indicates that the bottom of the landfill may be just above or in contact with the groundwater. The depth to the water table is estimated to be approximately 30 ft. At present, the Horn Rapids landfill is a designated curlew nesting area, and access is restricted.

No detailed waste inventory is available. One cell of the landfill is marked by signs indicating that asbestos is buried there. Nearby there are two locations, several yards apart, that have signs with the legend "Burial Site". These apparently mark an earlier trench, but what was buried there is unknown. Used tires occupy an open trench at the northern end of a landfill cell. Another area is surrounded by a low berm and occupied by a dark gray-brown mud-like substance that exhibits mud-cracks. This site appears to have been used for disposal of unknown liquid materials, possibly including sewage sludge and/or fly ash.

4.1.1.7 UN-1100-6 Site. In the course of the site inspection for the 1100-EM-1 operable unit waste sites, two additional potential waste sites were found. The first was an area of what appeared to be asphalt or oily material on the face of the sand dune north of the 1171 Building. The second was a patch of oily, discolored soil in an elongated natural depression near an abandoned irrigation canal and adjacent to the railroad tracks northwest of the 1171 Building. Grab samples of surface soils were taken from each of these sites. Subsequent discussions with 1100 Area personnel revealed that the first site was the remnant of an asphalt emulsion applied in an attempt to stabilize the sand dune in the early 1960s. Results of the analysis for the soil sample are generally consistent with asphalt, and this site will not be considered further. However, the sample from the second site was found to contain measurable concentrations of two phthalates, nine unknown acid-base neutrals, and elevated total organic carbon (TOC). Hence, this site has been designated as the "discolored-soil" site and will be investigated further. This site appears to be the location of at least one, and possibly several, incidents where one or more drums of liquid material were poured onto the ground.

4.1.2 Interactions with Other Operable Units

Two additional operable units have been identified in the 1100 Area. These are designated 1100-EM-2 and 1100-EM-3 (Figure 1-2). Geographic boundaries are not precisely defined, and there is overlap between 1100-EM-1 and 1100-EM-2. The primary criteria for grouping into operable units are waste characteristics and the nature of the facility. The waste locations contained in 1100-EM-1 are those that are thought to have the greatest potential for contaminant migration.

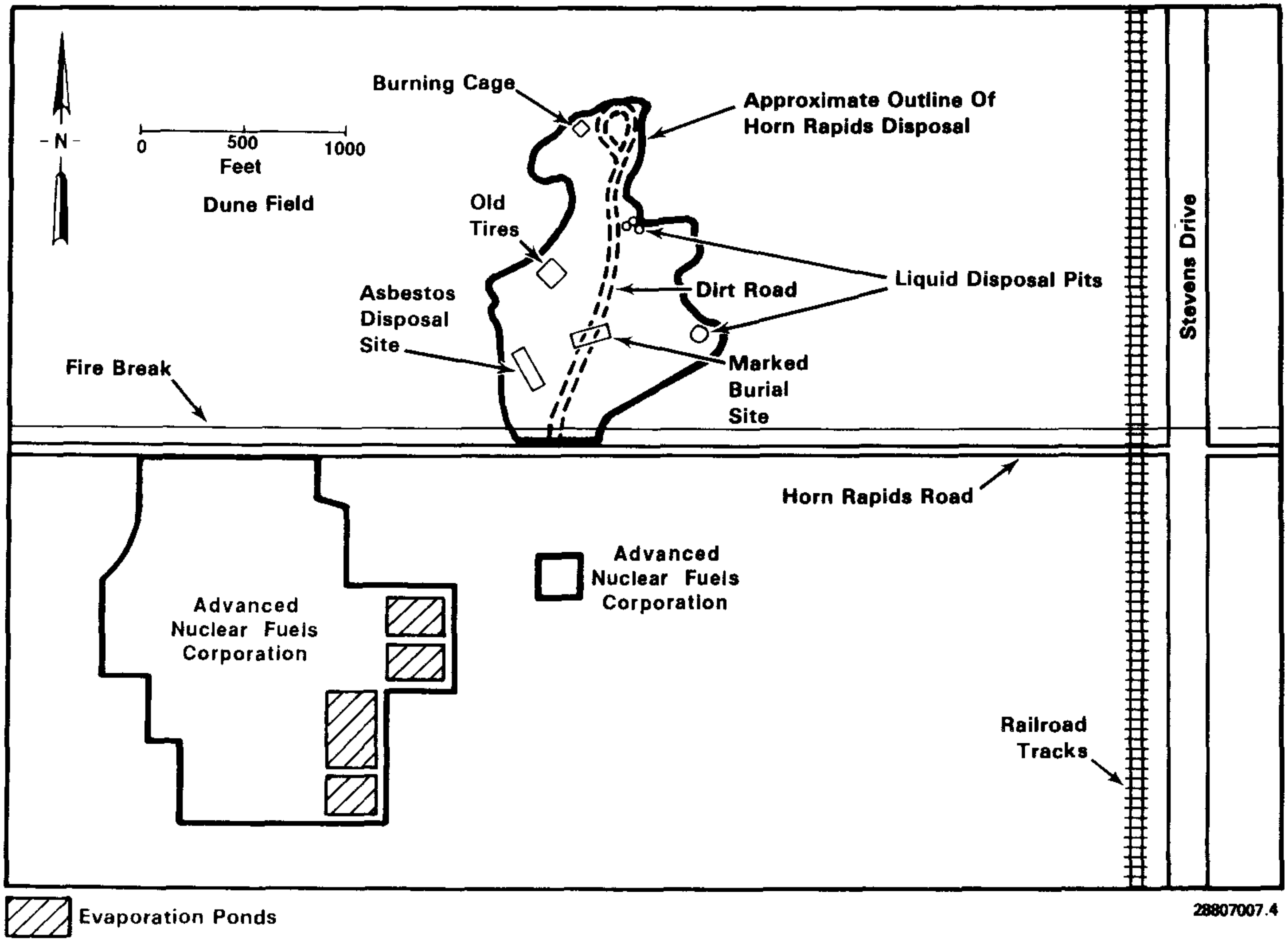

Figure 4-3. Horn Rapids Landfill.

The 1100-EM-2 operable unit consists of additional locations or waste staging areas in the vicinity of the 1171 Building. These units are in the same general vicinity as the battery acid pit (1100-1), the antifreeze tank (1100-4), and the radioactive contamination spill site (1100-5).

The 1100-EM-3 operable unit is located in the 1100 Area and the 3000 Area east of Stevens Drive. Although geographically distinct from 1100-EM-1 and 1100-EM-2, it may contain similar wastes. The 1100-EM-3 operable unit is located between the 1100-EM-1 operable unit and the north Richland well field.

Although both 1100-EM-2 and 1100-EM-3 contain sites not specifically addressed in this RI/FS, they represent potential sources of similar types of contamination. This must be accounted for in conducting the investigation for groundwater contamination associated with the 1100-EM-1 operable unit.

The 1100-EM-2 and 1100-EM-3 operable units are assigned a lower priority ("C") in the Action Plan on the basis of waste characteristics and volume, and potential for contaminant migration.

In addition to DOE waste sites identified in the three operable units, other waste sites or potential sources of contamination unrelated to DOE Hanford activities exist in the vicinity of the 1100 Area. These include the nuclear fuels processing facility operated by Advanced Nuclear Fuels, the Lamb-Weston potato processing plant, the city of Richland landfill, and several small businesses, including at least one gas station and one automobile machine shop/repair facility.

4.1.3 Summary of Existing Operable Unit Data

Data pertaining to possible contamination of soil and/or groundwater resulting from waste disposal operations in 1100-EM-1 are limited. Existing data consist of the following: (1) two analyses by the State of Washington of well-head water from the north Richland and Duke well fields operated by the city of Richland, (2) two analyses by the Hanford Environmental Health Foundation (HEHF) of well-head water from the north Richland well field, (3) 11 preliminary analyses of water samples from wells in the 1100 and 3000 Areas and vicinity taken during 1986, (4) analyses of water samples from seven wells in the vicinity of the 1100 Area conducted in August 1988, (5) analyses of water samples from five monitoring wells installed along the eastern margin of the 1100 Area in November 1988, and (6) eight surface soil samples from the 1100 Area. The groundwater data do not serve to establish whether or not the 1100-EM-1 operable unit is a source of contamination. Given below is a brief summary of existing data. The analytical data obtained from these studies can be found in Appendix B.

The analyses of well water from the city of Richland well fields indicated that trihalomethanes (bromoform, bromodichloromethane, and chloroform) were the only regulated compounds present in the groundwater and were only detected in samples from the north Richland well field. The concentrations of trihalomethanes detected were considerably less than the allowable values under state water quality standards. Trihalomethanes are commonly associated with chlorinated water and are not believed to have come from the 1100 Area.

Analyses of samples from wells in the 1100 and 3000 Areas and vicinity have also indicated the presence of regulated compounds in the groundwater. The data obtained from the 1986 sampling (Appendix B) indicates the presence of methylene chloride, bis(2-ethylhexyl) phthalate, and several metals (barium, cadmium, and lead). Well 11-41-13C (3000-D-1), which is located in the vicinity of the 1100-2 and 1100-3 disposal pits, showed a concentration of 20 parts per billion (p/b) of methylene chloride. However, concerns regarding details of well construction, the age of the wells, and the procedures used for collection and analysis of the samples suggest the data may not be reliable. Analyses of samples taken during August 1988 showed that bromodichloromethane, chloroform, 1,1,1-trichloroethane, and trichloroethene are present in the groundwater in the vicinity of the 1100 Area. The concentrations of these compounds were all at least 20 times less than concentration levels specified in state water quality standards. However, the wells are not optimally located to detect potential dispersal plumes associated with the sites. Hence, the degree and extent of contamination cannot be adequately judged.

In October 1988, five monitoring wells were installed in the area between the 1100-EM-1 waste sites and the north Richland and Duke wells. The purpose of these wells is to detect any contaminants that may be migrating from the 1100 Area waste sites toward the water supply wells. Chemical analyses of water samples obtained from these wells in early November were conducted by U.S. Testing and Pacific Northwest Laboratory (PNL). Results indicated that all constituents are below drinking water standards. Methylene chloride was detected in initial samples from three of the wells at concentration levels as high as 78 p/b. However, subsequent sampling and analyses by PNL have failed to detect methylene chloride (detection limit 3 p/b). Investigation of the problem indicates that this is probably the result of contamination during the sampling process. Results of these analyses are included in Appendix B.

Eight preliminary surface soil samples were taken in March 1988 from several sites in the 1100 Area and vicinity. Of the samples taken from the battery acid pit (1100-1), the "paint and solvent pit" (1100-2), and the "antifreeze and degreaser pit" (1100-3), only those from the 1100-1 site had elevated concentrations of regulated compounds. The samples from 1100-1 contained elevated levels of lead and possibly slightly elevated levels of mercury, chromium, and arsenic. One sample from 1100-1 also contained 1.3 p/b of the polychlorinated biphenyl (PCB) arochlor 1254.

The sample from discolored soil at the 1100-6 site was found to contain elevated organic carbon (353 p/m), bis(2-ethylhexyl) phthalate (170 p/m), di-n-octyl phthalate (82 p/m), and nine unknown aliphatic hydrocarbons with indivudual concentrations estimated at 22 to 36 p/m.

Results of all soil sample analyses are included in Table B-1, Appendix B.

4.1.4 Conceptual Model

This section describes a conceptual model to support qualitative risk assessment and RI/FS planning for the 1100-EM-1 operable unit. Guidance from EPA's Data Quality Objectives for Remedial Response Activities (EPA 1987a) requires the conceptual model to describe the site and its environs and to present a hypothesis regarding the dynamics of contaminant migration at the site.

The conceptual model incorporates available data on site conditions, waste sources, pathways, and receptors and provides a basis for evaluation of potential risks to human health, safety, and the environment. The conceptual model includes all known or suspected sources of contamination, types of contaminants, affected media, and known or potential routes of migration and all known or potential human and environmental receptors. Data for the 1100 Area are limited and, in many cases, assumptions must be made, or conditions must be extrapolated from other locations. However, the present conceptual model contains sufficient detail to provide a basis for planning initial field investigation efforts. The conceptual model will be revised as necessary to incorporate data obtained from field investigations.

The current understanding of the 1100-EM-1 operable unit conceptual model is depicted in Figure 4-4. This generic conceptual model identifies potential waste sources, release mechanisms, pathways, and receptors, as well as other sources of recharge or discharge from the unconfined aquifer that may affect contaminant migration.

All of the individual sites in the 1100-EM-1 operable unit exhibit interior drainage. No standing water has been observed at any of the sites, and the general character of surface sediments is such that the presence of standing water at the ground surface for any significant time period is unlikely. Hence, drainage to surface water is not considered a credible pathway for contaminant migration.

Because of existing soil cover, volatilization of wastes is not considered a credible release mechanism.

Air entrainment and transport of contaminated fugitive dust is considered unlikely until the sites are disturbed.

Figures 4-5 and 4-6 present generalized east-west geologic cross-sections in the 1100 Area and vicinity. The cross-section shown in Figure 4-5 passes through the battery acid pit (1100-1) and the north Richland well field. The cross-section shown in Figure 4-6 passes through the Horn Rapids landfill and illustrates the potential for direct or nearly direct contact between groundwater and waste at the Horn Rapids landfill. These cross sections reflect the current understanding of geologic and hydrologic characteristics based on limited and extrapolated data. Figures 4-4, 4-5, and 4-6 are used to support the conceptual model description that follows.

4.1.4.1 Waste Sources. Known and suspected waste types are given for each location in Table 2-1. With the exception of 1100-4 and the Horn Rapids landfill, all are the result of waste discharge directly to the soil. The 1100-4 tank was an antifreeze-holding tank suspected of leaking. The tank

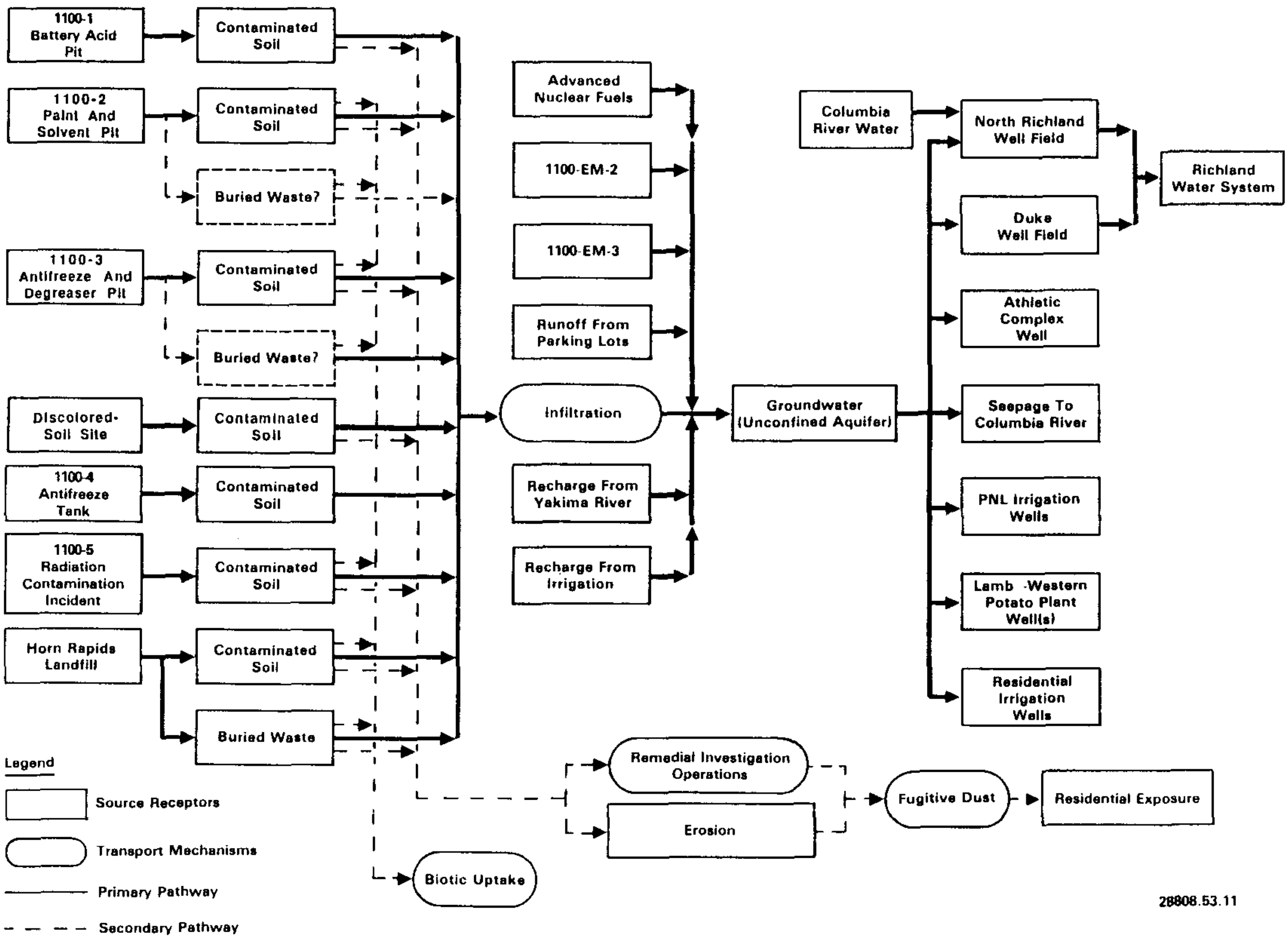

Figure 4-4. 1100-EM-1 Operable Unit Conceptual Model.

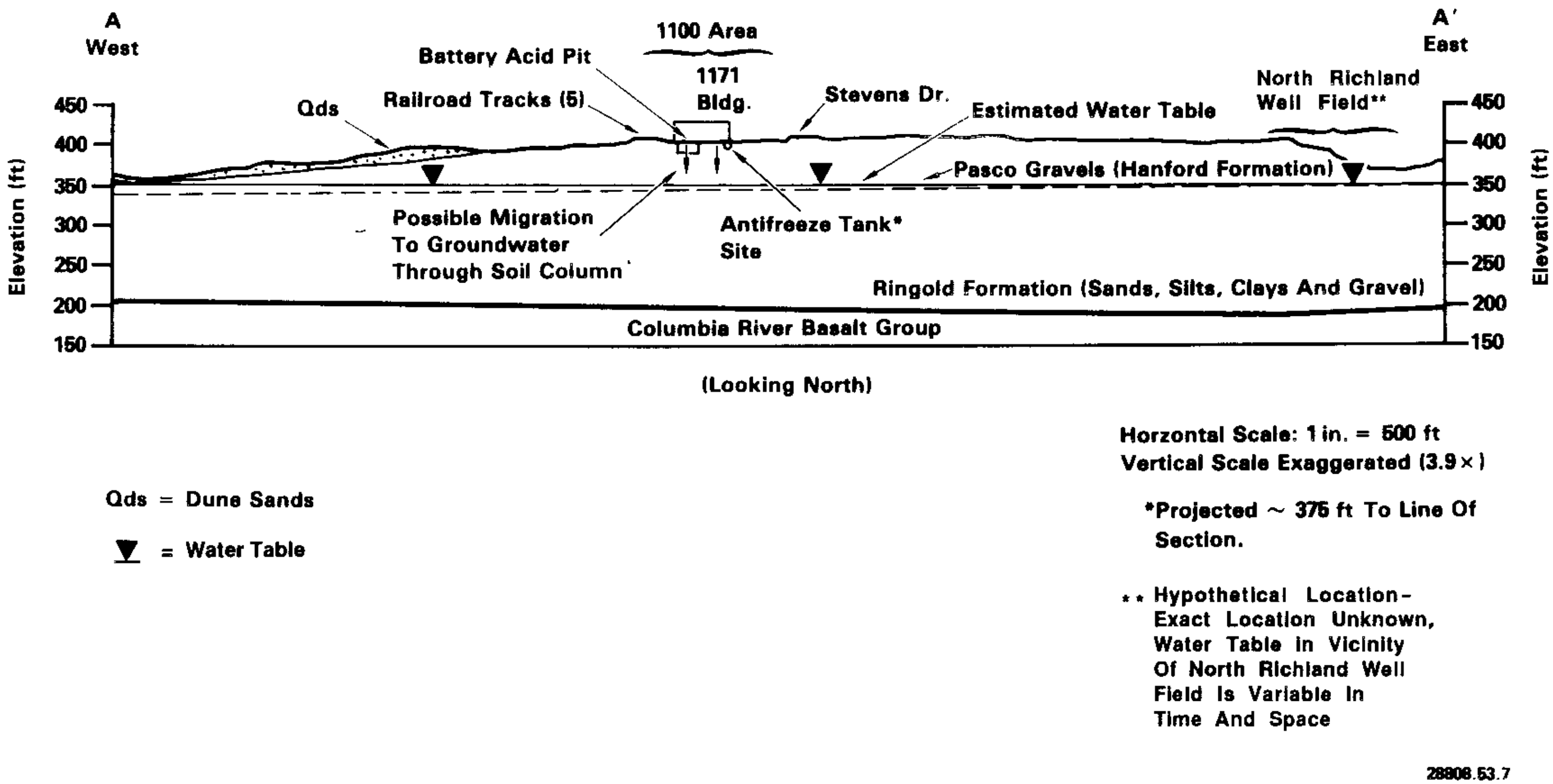

Figure 4-5. Battery Acid Pit and Antifreeze Tank Site Cross-Section.

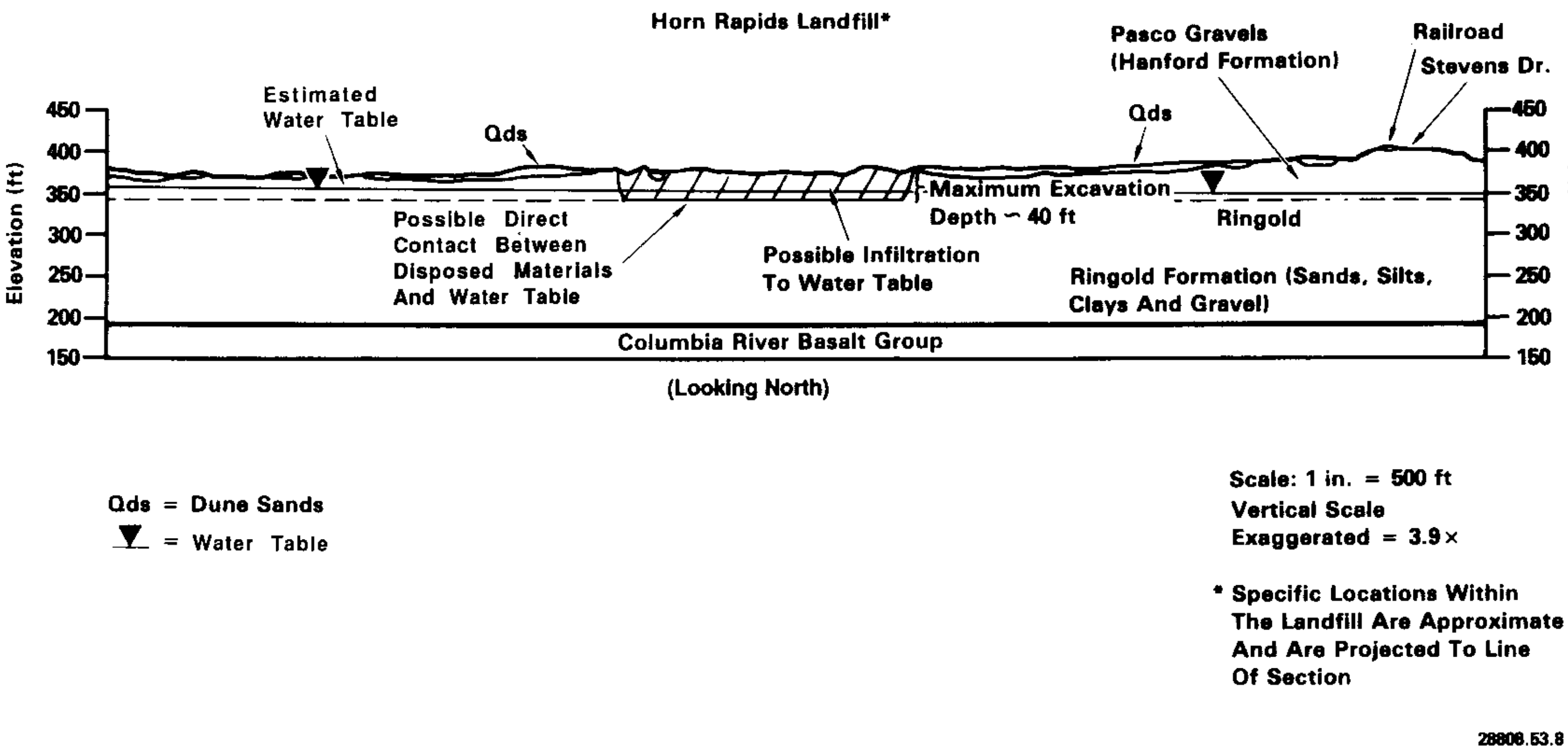

Figure 4-6. Horn Rapids Landfill Site Cross-Section.

has since been removed. Hence, contaminated soil is the primary potential source of contaminants. The Horn Rapids landfill may contain buried drums and other forms of buried waste. Buried drums or other types of buried waste containers may also exist at 1100-2 and 1100-3. Although there are no records to confirm the presence of buried waste containers, the possibility cannot be discounted at this time.

4.1.4.2 Pathways. The primary contaminant migration pathway is assumed to be infiltration and percolation through the soil column into the unconfined aquifer.

Contaminants from waste sites in 1100-EM-1 are assumed to have traveled through eolian sands and glaciofluvial sediments to reach the unconfined aquifer at a depth of approximately 50 ft below the surface. At the Horn Rapids landfill, the waste may be in direct contact or very close to the water table. In this case, contaminants may also be leached from the waste.

Groundwater beneath the 1100 Area occurs in the unconfined aquifer of the Pasco gravels and in sands and gravels of the Ringold Formation. The base of the unconfined aquifer is determined by the presence or absence of a silty layer at a depth of about 85 ft below ground surface. It has been encountered in the 1100 Area wells, but its lateral extent (or lateral continuity) is unknown. In the 300 Area to the north and east, the silt unit is not laterally continuous (Lindberg and Bond 1979, Figure 4-1, p. 4-2). When present, the silt unit defines the base of the unconfined aquifer. A confined or semiconfined aquifer may occur in the sands and gravels beneath the silt unit when present. When absent, the base of the unconfined aquifer is probably the clay layer (at about 175 ft) in the lower portion of the Ringold Formation (the "blue clay member"). Recharge to the unconfined aquifer occurs from the Yakima River, agricultural and residential irrigation, the Lamb-Weston potato processing plant waste treatment system, and the north Richland well field. Only minor recharge results from natural precipitation.

Until recently, the 1100 Area was not included within the Hanford groundwater monitoring network, so detailed water table maps and water chemistry data are not available.

Groundwater flow conditions in the vicinity of the 1100 Area are assumed to vary both spatially and temporally, as a result of lateral and vertical variations in aquifer properties and the distribution and operation of various discharge and recharge mechanisms. Variations in aquifer properties are related to the position of the contact between the Pasco gravels and the Ringold Formation relative to the groundwater table, variations associated with the heterogeneous nature of both formations, and the possible existence of buried paleochannels. In addition, seasonal agricultural and residential irrigation, recharge operations at the north Richland well field, and variations in pumping rates at the various wells in the vicinity will result in both spatial and temporal variations in groundwater flow patterns. Variations in Columbia River stage are not expected to significantly affect groundwater flow in the vicinity of the 1100 Area. the basis for this assumption is the distance from the river (approximately 1 mi) and the typically small variation in river level resulting from regulation of flow at dams both upstream and downstream. The effects of variation in the Columbia River level is discussed in more detail in Appendix A.

Travel times for contamination to reach the north Richland well field from potential sources in the 1100 Area are difficult to estimate at this time because of the lack of available data concerning the volume and frequency of waste disposal, as well as details of the hydrogeologic system. Ignoring travel time in the vadose zone, adsorbing qualities of the soil, chemical reactions of the waste with the soil, and other contaminant transport factors such as dispersion, estimates of minimum travel time could be calculated by estimating groundwater travel time in the saturated soil zone. However, estimates of groundwater travel time rely heavily on hydraulic conductivity that may vary as much as three orders of magnitude in Ringold Formation and glaciofluvial sediments. In the 1100 Area and vicinity the water table is generally within the lower portion of the glaciofluvial sediments, but at some locations it may lie within the Ringold Formation (Figures 4-5 and 4-6). Paleochannels in the upper surface of the Ringold Formation may affect groundwater flow in the 1100 Area as they do in the 300 Area (Lindberg and Bond 1979, pp. 4-7 to 4-12).

For example, using a hydraulic conductivity of 20 ft/d (a low value for the Ringold Formation), a hydraulic gradient of 10 ft/mi (or 0.002), and an effective porosity of 15%, groundwater travel time for the 3,150-ft distance to the north Richland well field is 34 yr. Changing the hydraulic conductivity to 20,000 ft/d (a high value for the Pasco gravels), the travel time would be 12.5 d. These estimates represent bounding values. As more information becomes available during the RI, better estimates of groundwater flow will be possible and, in turn, these estimates will help determine contaminant travel time.

Ultimately, any contaminated groundwater from the 1100 Area will probably reach the Columbia River. However, any contamination reaching the Columbia River through the groundwater system is likely to be tremendously diluted by the very large volume of water in the Columbia River stream flow. This large dilution creates a problem in the detection and monitoring of low levels of contamination from potential 1100 Area sources. As a result, the emphasis during the early phases of the RI will be to characterize the soil and groundwater beneath and downgradient of the 1100 Area to determine whether contamination has reached the groundwater system. Should contamination be discovered in the groundwater, plans for monitoring the Columbia River will be developed for later phases of the RI/FS.

A possible secondary pathway is fugitive dust resulting from site activities or construction. Deposition of fugitive dust in the Richland well field ponds or in other accessible areas represents a minor concern, but must be considered to assess the cumulative impact of 1100-EM-1.

Another possible secondary pathway by which contaminants may reach the environment is uptake by biota. At 1100-1, 1100-4, and 1100-5, there is no vegetation. Each of these sites is located within an area where vegetation is precluded by the facility.

Sites 1100-2, 1100-3, and the Horn Rapids landfill are characterized primarily by sagebrush and cheatgrass and a population of rodents and birds. The probability of biotic uptake at these sites is very low due to the sparse density and shallow rooting depths of the plants involved.

4.1.4.3 Receptors. The most significant potential receptor for contaminants that reach the unconfined aquifer is the water supply system for the city of Richland. This system supplies water for a population of approximately 33,600 people (1980 census). For the purposes of this conceptual model, the wells nearest the 1100 Area will be considered receptors. This includes the north Richland well field and the Duke wells. Other possible receptors include the PNL irrigation wells, the Horn Rapids athletic complex well, well(s) at the Lamb-Weston potato processing plant, and various residential irrigation wells. In general, the contamination problem in the 1100 Area can be defined in terms of contaminant levels in water withdrawn at the various wells.

4.2 SAMPLING OBJECTIVES

The SAP is a major component of the overall RI/FS work plan and provides specific direction for conduct of the RI. The RI/FS will be conducted in phases, as indicated in Figure 1-2. The RI and the FS will proceed in parallel, with the RI providing data to support FS activities.

The discussion in Section 4.1.3 and available analytical data presented in Appendix B indicate that potential contaminants have been detected in the 1100 Area. However, a preliminary analysis of the limited data available and comparison with proposed Federal and State ARARs indicate that allowable levels have not been exceeded. As such, there is no evidence to suggest that the contamination constitutes an adverse risk or immediate threat to public health or the environment. Further sampling will provide additional data on which to determine whether a remedial action is warranted, based on an evaluation of ARARs and potential public health risks via relevant exposure pathways. In the event that further analysis continues to indicate that there is no adverse risk to public health and the environment, then the only applicable alternative would be no action and the RI/FS process would terminate on formalized acceptance of this conclusion via the record of decision (ROD).

It is anticipated that both the conceptual model and the SAP will be revised as the work proceeds to accommodate an improved understanding of site conditions and specific data requirements associated with evaluation of remedial alternatives. Initially, the questions to be answered are whether or not contamination exists at the site, what contaminants are present, and whether or not contaminant levels exceed regulatory limits or action levels. Other data will be collected to improve the overall understanding of site conditions.

Because relatively little specific data are available for the 1100 Area, Phase 1 of the RI will be performed in two phases, designated as Phase 1A and 1B. This approach is being taken to maximize the benefit associated with relatively expensive investigation activities such as drilling and groundwater sampling by first finding likely places for sampling with less sensitive, inexpensive survey techniques.

Phase 1A activities will consist of survey techniques conducted to identify zones of potential contamination (e.g., "hot spots") and to identify probable contaminants. Techniques to be used under Phase 1A include evaluation of aerial photography, geologic mapping, soil-gas surveys, and geophysical surveys.

Phase 1B activities will consist of more detailed investigation and sampling, such as auger holes, soil borings, and monitoring wells to investigate anomalies identified in Phase 1A. Specific locations for sampling activities under Phase 1B will be determined on the basis of information obtained from Phase 1A.

Phases 1A and 1B are based on location and sampling of zones of contaminated soils. In the event that buried drums or other waste containers are detected by Phase 1A survey activities, auger holes and soil borings planned under Phase 1B will be relocated as necessary to avoid penetrating waste containers. The SAP will be modified as appropriate to include provisions for exhumation and/or sampling of the contents of buried waste containers. The methods to be used will be dependent on the circumstances.

Specific objectives of Phases 1A and 1B of the RI are as follows.

- Determine nature and extent of contamination.
  - Waste constituents/types
  - Waste characteristics
  - Contaminant concentration (including spatial variability)
  - Potential contaminant inputs from nearby industrial processes or other operable units
- Obtain data necessary to protect worker health and safety during remedial investigation activities.
- Obtain data to improve the preliminary conceptual model.
- Provide data to conduct a preliminary baseline risk assessment.

Subsequent phases of the RI will have the following objectives.

- Determine characteristics of primary contaminant transport pathways.
  - Vadose zone characteristics
  - Aquifer and aquitard characteristics
  - Identify and develop quantitative estimates of aquifer perturbations
  - Biotic characteristics

  - Meteorological/dispersion parameters

- Determine contaminant transport characteristics for each credible pathway.
  - Nature and rate of contaminant release from waste source
  - Waste degradation characteristics
  - Contaminant mixing/dispersion
  - Possible synergistic/antagonistic effects
  - Contaminant sorption/retention
- Obtain sufficient data to conduct risk assessments and assess the threat to public health.
- Obtain sufficient data to identify and perform preliminary screening of candidate remedial action alternatives.
- Obtain sufficient data to determine what technically feasible and cost-effective measures can be applied to achieve regulatory compliance.
- Obtain sufficient data to estimate the resources, costs, and time frames required to implement the recommended remedial measures.

The phased sampling approach encourages timely identification of key data needs and ensures that data collection activities provide information relevant to the selection of a remedial action.

Each of the locations in the 1100-EM-1 operable unit is unique and will require modifications based on individual conditions. For example, 1100-1, 1100-4, and 1100-6 are of limited areal extent, and their locations are fairly well known. Hence, sampling activities can be started with minimal Phase 1A activities. Locations 1100-2, 1100-3, and the Horn Rapids landfill are much larger and will require areal screening by means of Phase 1A survey techniques to identify likely areas for Phase 1B borings. The final number and size of the areas to be investigated in detail, as well as the final number of pits, borings, and monitoring wells will depend to a large degree on the results of the Phase 1A surveys.

4.3 DATA NEEDS AND DATA QUALITY OBJECTIVES

To define data needs for planning the RI, it is necessary to identify data users and determine what uses will be made of the data. Existing data can then be evaluated in terms of adequacy with regard to their proposed uses in the RI/FS. In this way, data gaps that must be satisfied can be identified, and the RI can be focused to obtain the needed data in a cost-effective manner. Most data uses are associated with decisions inherent to the RI/FS process. Major decisions associated with the RI/FS are shown in Table 4-1.

The goal of this section is to identify the data needs that must be satisfied to make the decisions indicated in Table 4-1 and to present preliminary DQOs that will provide a basis for planning the initial phase of the data collection program.

Table 4-1. Decisions Involved in the Remedial Investigation and Feasibility Study Process.

For Each Location: • Does contamination exist? • What contaminants are present?
For Each Contaminant at Each Location: • What are the likely pathways or mechanisms for contaminant transport or migration?
For Each Pathway and Each Contaminant at Each Location: • Do present contaminant concentrations exceed allowable levels? - Is immediate action necessary? - Is remedial action required? • What is the present extent of contamination? • What is the projected extent of contamination? • Do present or projected contaminant levels exceed regulatory limits at (or beyond) the boundary of compliance? • What hazard is associated with no action? • Is cosntainment or source control feasible? • Is treatment or resource recovery feasible? • Is removal action feasible? • What remedial actions appear to be appropriate? • What is the recommended alternative?

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Phase 1A RI work is scheduled to start prior to the formal approval of this work plan by the regulators. The RI work will be confined to noninvasive methods such as geophysical surveys. This is anticipated to be an iterative process: after each phase of the RI, existing data will be evaluated to assess any data gaps that must be addressed in the next phase of the data collection effort, and the DQOs will be revised accordingly. As the overall understanding of site conditions improves and the range of potential remedial alternatives is narrowed, data gaps should become more limited. Once candidate RA alternatives have been completely identified, fully defining all data needs for evaluation and comparison of alternatives should be possible.

4.3.1 Data Users

Data users can be subdivided into two general categories: primary and secondary. Primary data users are those individuals or organizations directly involved in ongoing RI/FS activities. These activities include the following:

- RI/FS planning and implementation
- Evaluation and interpretation of data
- Assessment of data needs and development of DQOs
- Identification and evaluation of treatment technologies and remedial alternatives
- Performance and risk assessment
- Project management and oversight
- Site-specific decision making.

Primary data users include the following:

- Remedial-project managers
- Unit managers from EPA, Ecology, and DOE
- RI and FS coordinators
- Technical contributors.

Secondary data users are those individuals or organizations who rely mainly on outputs from the RI/FS studies to support their activities. Secondary data users include the following:

- Agency for Toxic Substances and Disease Registry, for public health evaluation
- The general public and special-interest groups.

Most data needs are defined by primary data users. Secondary data users may also provide inputs to the decision makers and primary data users by communicating generic or site-specific data needs or regulatory requirements or by comment or question during the review process.

4.3.2 Data Uses

Most data uses during the RI/FS fall into one or more of four general categories:

- Site characterization

- Worker health and safety
- Public health evaluation and risk assessment
- Evaluation of remedial alternatives.

Site characterization refers to the determination and evaluation of the physical and chemical properties of each location, development and refinement of the conceptual model, and evaluation of the nature and extent of contamination. This category includes geologic, hydrologic, and meteorologic data as well as data on specific contaminants.

The worker health and safety category includes data collected to establish the level of protection for workers during various RI activities. In addition, these data are used to determine if there is concern for the population living in the vicinity of each location.

Data collected to conduct the public health evaluation and risk assessment include input parameters for various performance assessment models, site characteristics and contaminant data required to evaluate the threat to public health and welfare posed by each location.

Data collected to support evaluation of remedial alternatives include site characteristics and engineering data required for initial screening of alternatives, feasibility-level design, and preliminary cost estimates, as well as data required to support performance assessment.

4.3.3 Data Needs

Relatively little reliable data are presently available for the 1100 Area. Hence, the RI/FS is conducted in phases, and the goals of the initial phase are to locate any contamination, identify the contaminants, and make a determination as to whether or not regulatory criteria have been exceeded or if an immediate hazard to public health or welfare exists. Data uses to be accommodated by Phase 1A and 1B activities are primarily site characterization and worker health and safety. However, the importance of public health risk evaluation and the evaluation of remedial alternatives is recognized. After a contamination hazard is verified, specific contaminants are identified, and site characteristics are better known, later phases of the RI/FS will focus on evaluation of risk to human health and/or the environment and identification and evaluation of remedial alternatives. These subsequent phases may not be necessary if contaminants resulting from waste disposal at individual locations do not exist at levels in excess of those specified by the ARARs and if no hazard to human health or the environment exists.

Individual data needs that must be satisfied to conduct a preliminary assessment of the hazard to human health and the environment are as follows.

- Determine nature and extent of contamination.
  - Determine data representative of background to establish baseline parameters.

- Locate areas of potential contamination: Obtain sufficient data to achieve a very high probability of locating a significant volume of contaminated soil.

- Identify contaminants: Obtain sufficient samples and conduct appropriate analyses to achieve a very high probability of detecting the presence of any contaminant in either soil or groundwater.

- Determine levels of contamination: Obtain sufficient media samples and conduct analyses with appropriate detection limits such that comparison with ARARs is possible. Obtain sufficient replicate samples, blanks, and spikes to estimate the precision and accuracy of the concentration data.

- Define conceptual model (site characterization).

  - Stratigraphy: Detect significant stratigraphic horizons and determine contacts between individual units.

  - Vadose zone: Determine or estimate vadose zone properties (infiltration, porosity, saturation, hydraulic conductivity, and specific retention) to the degree necessary to support preliminary modeling of contaminant transport.

  - Identify aquifers and aquitards: Identify significant aquifers and aquitards that control subsurface water flow and contaminant transport. Identify zones of perched water conditions.

  - Piezometric surface: Determine the depth to groundwater level at sufficient points to determine the magnitude and direction of hydrologic gradient for each site to a high level of confidence; monitor groundwater level and gradient with time.

  - Aquifer properties: Determine aquifer properties (porosity, transmissivity, hydraulic conductivity, storage coefficient, and dispersion coefficients) to the degree necessary to support preliminary modeling (modeling of the no-action alternative) of contaminant transport.

The specific sampling and analysis program to satisfy these data needs is discussed in Section 4.4.

4.3.4 Data Quality Objectives

The DQOs are qualitative and quantitative statements that specify the quality of data required to support decisions during remedial response activities. A variety of analytical methods are generally available to provide data. In general, increasing accuracy and precision are obtained with increasing cost and time. Therefore, the analytical level used to obtain data should be commensurate with the intended use. Table 4-2 defines five analytical levels based on overall data quality.

Table 4-2. Analytical Levels.

Level	Description
Level I	Field screening or analysis using portable instruments. Results are often not compound specific and not quantitative, but they are available in real time. This is the least costly of the analytical options. Instruments may not respond to all compounds and may not be able to identify compounds. If the instruments are calibrated properly and data are interpreted correctly, Level I techniques can provide an indication of contamination.
Level II	Field analyses using more sophisticated portable analytical procedures such as gas chromatography for organics and atomic absorption or X-ray fluorescence for metals. The instruments may be set up in a mobile laboratory on site. Results are available in real time or within several hours and may provide tentative identification of compounds or be analyte specific. Data are typically reported in concentration ranges, and detection limits may vary from low parts per million to low parts per billion. Data quality depends on the use of suitable calibration standards, reference materials, sample-handling procedures, and on the training of the operator. In general, Level II techniques and instruments are mostly limited to volatiles and metals.
Level III	All analyses performed at an offsite analytical laboratory. Level III analyses may or may not use contract laboratory program (CLP) procedures but do not usually use the validation or documentation procedures required of CLP Level IV analysis. Detection limits and data quality are similar to Level IV, but results will generally be available in a shorter time.
Level IV	Contract laboratory program routine analytical services. All analyses are performed in an offsite CLP analytical laboratory following CLP protocols. There is a generally low parts per billion detection limit for substances on the hazardous substance list but analysis may also provide identification of compounds not on the hazardous substance list. Sample results may take several days to several weeks, and additional time may be required for data validation. Level IV results have known data quality supported by rigorous quality-assurance and quality-control protocols and documentation.
Level V	Analysis by nonstandard methods. All analyses are performed in an offsite analytical laboratory that may or may not be a CLP laboratory. Method development or method modification may be required for specific constituents or detection limits, and additional lead time may be required. Detection limit and data quality are method specific. The CLP special analytical services are Level V.

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Individual DQOs and appropriate analytical levels associated with each data need are given in Table 4-3. In general, DQOs for Phase 1 of the RI are intended to obtain data of sufficient quality and quantity to accomplish the following.

- Locate areas of contaminated soil or groundwater.

Table 4-3. Data Quality Objectives. (Sheet 1 of 2)

Data need	Method	Analytical level	Data quality objective
Determine nature and extent of contamination			
Locate areas of contamination	Detailed site inspection	N/A	Locate surface expressions of waste burial areas, discolored soil, and areas of affected vegetation.
	Ground-probing radar	I	Achieve high degree of confidence in locating buried waste containers and significant volumes of disturbed soil.
	Electromagnetic survey	I	Locate variations in soil conductivity associated with the presence of contaminants or buried metallic objects.
	Soil resistivity	I	Locate lateral and vertical variations in soil resistivity associated with the presence of contaminants.
	Magnetometer	I	Locate buried ferrometallic waste containers such as steel drums.
	Metal detector	I	Locate buried metallic objects such as drums, tanks, or pipes.
	Radiological survey	I	Achieve a very high degree of confidence in locating areas of surface radioactive contamination.
Detect contaminants	Soil-gas survey	II	Detect and identify organic vapors in the vadose zone to the parts-per-billion range.
	Air quality monitoring	II-III	Achieve a high level of confidence in detecting and identifying any airborne contaminants emitted from the site(s), either at present or as a result of remedial investigation activities.
	Ambient air monitoring with flame ionization detectors, photo ionization detectors, or colormetric tubes	I	Achieve a very high degree of confidence in detecting contaminants, to protect worker health and safety.
	Radiological monitoring	I	Achieve a very high degree of confidence in detecting radionuclides, to protect worker health and safety.
	Groundwater monitoring wells	I	Measure and record water quality parameters during well purging.
Identify contaminants and determine concentration levels	Vadose zone holes and soil samples	IV	Obtain samples and test for organic and inorganic contaminants. Achieve high probability of detecting any potential contaminants present at levels defined in ARARs.

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Table 4-3. Data Quality Objectives. (Sheet 2 of 2)

Data need	Method	Analytical level	Data quality objective
	Samples from monitoring wells and water supply wells	IV	Obtain samples from monitoring wells and water supply wells. Test for organic and inorganic contaminants. Achieve a very high probability of detecting any potential contaminant with detection limits below action levels defined in ARARs.
Support conceptual model development/preliminary risk assessment			
Contaminant source characteristics	See above		
Site stratigraphy	Geologic logs of vadose zone holes and groundwater monitoring wells	N/A	Define general stratigraphic and lithologic units in 1100 Area. Define contacts between units.
	Geophysical logs of groundwater monitoring wells	I	Correlate stratigraphic and lithologic units between holes.
Site hydrogeology	Geologic logs of vadose zone holes and groundwater monitoring wells	N/A	Identify aquifers and aquitards.
	Geophysical logs of groundwater monitoring wells	I	Identify aquifers and aquitards. Obtain rough estimates of in situ bulk density and porosity
	Aquifer tests	N/A	Obtain rough estimates of aquifer transmissivity and storage coefficient.
Groundwater flow regime	Measure water levels in groundwater monitoring wells and selected vadose zone holes	I	Determine general hydraulic gradient in selected areas by solution of the three-point problem. Prepare contour maps of potentiometric surface to estimate direction and magnitude of hydraulic gradient.
Contaminant/ soil interactions	Geochemical analysis of soils: leaching studies	III or V	Determine contaminant release rates and retardation properties of soils.
Vadose zone transport properties	Moisture characteristic curves for vadose zone soils	N/A	Determine hydraulic conductivity of vadose zone soils as a function of porosity and degree of saturation.
Perturbations to groundwater flow regime	Estimate contribution of specific perturbations	N/A	Determine impact of perturbations to groundwater flow regime (direction and rate of groundwater flow)

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- Detect the presence of any likely contaminant, and determine its concentration level to the extent that a comparison to ARARs and other action levels can be made.

- Determine site characteristics, contaminant properties, and probable contaminant transport pathways to the degree required to support a preliminary risk assessment.

- Protect worker health and safety during RI activities.

Once completed, the comparison to ARARs and the preliminary risk assessment will be used to determine the following.

- Do any of the individual locations pose an immediate threat to human health or to the environment?

- Do any of the individual locations pose a potential long-term risk to human health or the environment such that future RI/FS work is warranted?

- What are the site controls and levels of protection required of workers for performance of future RI work and site remediation?

The primary decision to be made on the basis of the Phase 1 RI data is whether or not remedial actions wil be required at each location. This decision can be stated in terms of statistical hypothesis (e.g., contaminant concentration levels within a specified area or volume do not exceed action levels specified in ARARs). The decision will be to accept or reject the hypothesis on the basis of data obtained from the RI. For such a decision there are four possible outcomes.

- Decision is made not to implement RA when true conditions are such that RA is not required (correct decision).

- Decision is made to implement RA when true conditions are such that RA is required (correct decision).

- Decision is made not to implement RA when true conditions are such that RA is required (Type II error).

- Decision is made to implement RA when true conditions are such that RA is not required (Type I error).

For this decision, the consequences associated with a Type II error are much more serious than those associated with a Type I error. For example, the decision not to implement a remedial action when it is actually required would mean that a significant hazard to human health and/or the environment may continue to exist. On the other hand, implementing a remedial action when it is not required represents primarily a waste of resources (which may divert resources from other contaminated sites) but does not result in any significant hazard to human health or the environment. Therefore, it is necessary to demonstrate that the probability of a Type II error is acceptably small. In other words, if no contaminants are found, the decision to terminate RI/FS activities at that location must be made to a high degree of confidence. On the other hand, if contaminants are found, the RI/FS will likely be continued. In this case, the only error possible is the Type I error, whose consequences are much less significant, at least in terms of risk to human health or the environment. Hence, the quantity and quality of data collected during Phases 1A and 1B of the RI must be sufficient to demonstrate the presence or absence of a particular contaminant to a high degree of confidence, but it is not necessary to determine the concentration or extent of contamination to the same level of confidence. The data necessary to fully evaluate concentration levels and to better define the extent of contamination can be obtained in a later phase of the RI. In the event that a Type I error has been made, subsequent RI activities will provide sufficient data to detect the error, and the RI/FS can be discontinued at that time. This will result in the most cost-effective approach, because the data collection effort necessary to fully define the extent of contamination will only be undertaken if contamination is detected.

Much of the work to be carried out under Phase 1 of the RI can be done at analytical Level I, II, or III to satisfy the DQOs for site characterization and detection of contamination. However, holding time limitations and sample availability effectively preclude archiving samples for chemical analysis. Therefore, soil and water samples will be submitted for laboratory analysis under analytical Level IV (CLP) protocols to ensure that data quality regarding concentration levels will be sufficient to satisfy DQOs associated with risk assessment and evaluation of remedial alternatives that may be developed in later phases of the RI/FS. This will avoid the need to repeat sampling events at the same point.

4.4 SAMPLING AND ANALYSIS PROGRAM

This section describes the field investigation program for the first phase of the RI. As indicated on Figure 1-2, an additional phase of the RI will be conducted as required to obtain specific data necessary to support FS activities. However, the requirements of the later phase cannot be completely defined at this time. Hence, a supplement to the SAP will be prepared to reflect the data obtained from the initial field investigation program defined herein.

There are three areas in which site investigation activities will be conducted. These are (1) vadose zone and groundwater, (2) air quality and meteorology, and (3) biota. The vadose zone and groundwater program will be subdivided into two phases, which are designated as RI Phase 1A and RI Phase 1B. The purpose of Phase 1A is to determine final locations for borings and monitoring wells based on nonintrusive survey techniques. The borings and monitoring wells will then be drilled in Phase 1B. Specific phases are less distinct for the air quality and meteorology program and the biota program. Sampling activities associated with these programs will be carried out concurrently with the vadose zone and groundwater program in the appropriate sequence.

4.4.1 Vadose Zone and Groundwater Characterization

Because of the proximity of the city of Richland wells and the importance of the groundwater pathway, the vadose zone and groundwater characterization program represents the bulk of the RI effort in Phase 1.

4.4.1.1 General Sampling Program. The field work will proceed in phases. These are designated as RI Phases 1A and 1B. In Phase 1A, the sites will be surveyed to lay out a sampling grid and to prepare accurate topographic maps of each site and the surrounding area. Each node (intersection of grid lines) will be marked in the field with a wooden stake. The spacing and orientation of the grid will be based on individual site characteristics. The next step will be to perform geophysical surveys of the waste sites. These geophysical surveys will include some or all of the following techniques: ground-penetrating radar, electromagnetic surveys, magnetometer surveys, or ground resistivity profiles and/or soundings. Following the geophysical surveys, a soil-gas survey will be conducted. The data obtained during the geophysical and soil-gas surveys can then be used to determine the final locations for vadose zone samples and groundwater monitoring wells.

The purpose of the geophysical surveys will be to determine the depth (and boundaries) of the various waste sites, locate buried metallic objects and structures (including mislocated pipes and utility lines as well as drums or other types of waste containers), and locate any anomalies that may indicate the presence of disturbed soil or contaminants. Table 4-4 indicates the uses of various geophysical methods. Geophysical surveys will be extended beyond the site boundaries as necessary to fully define subsurface conditions.

After the geophysical work is completed, soil-gas surveys will be conducted to detect and identify organic vapors within the pore space of the soil. A hollow probe is driven to a depth of approximately 4 ft, and an air sample is withdrawn for analysis by a gas chromatograph. Information from the soil-gas surveys will help identify areas with elevated levels of organic vapors that may be the result of volatile organic contaminants in the soil or migration of vapor from the groundwater through the soil. Additional sampling points outside of the site boundaries may be warranted to define the extent of any vapor plume.

Once the RI Phase 1A surveys are completed, the data will be evaluated, and the proposed vadose and groundwater sampling locations will be adjusted as required. Final locations of vadose zone sampling holes and groundwater monitoring wells will be chosen by the technical lead with the assistance of the technical staff so as to provide a maximum probability of detecting any contaminants, consistent with location constraints, health and safety considerations, and sampling objectives. The final number of sampling locations and monitoring wells in Phase 1B will depend on the number of anomalous areas detected during the Phase 1A surveys.

Table 4-4. Geophysical Techniques.

Method	Description	Use
Ground-penetrating radar	High-frequency electromagnetic waves transmitted into ground and reflected back to antenna.	Detect buried objects (drums, pipes, etc.). Detect zones of disturbed soil (trenches, etc.). Delineate near-surface stratigraphy and structure.
Soil resistivity profiling	Resistivity measurements made between electrodes with fixed spacing. Electrode array is moved along profile.	Detect and map lateral variations in soil resistivity. Map shallow contaminant plumes.
Soil resistivity sounding	Resistivity measurements made between electrodes with increasing spacing. Electrode array remains centered on a point while the spacing is increased.	Detect vertical variations in soil resistivity. Determine depth to groundwater and stratigraphy
Electromagnetic surveys	Measures variations in induced magnetic fields resulting from variations in soil conductivity. Can be conducted in profiling or sounding mode.	Detect buried metallic objects (drums, pipes, etc.). Detect zones of disturbed soil (trenches, etc.). Detect and map variations in soil conductivity associated with stratigraphy and/or contaminant content.
Magnetometer surveys	Measures variations in natural magnetic field.	Detect buried metallic (ferrous) objects (drums, pipes, etc.).
Metal detectors	Measures local fluctuations in magnetic field.	Detect ferrous and nonferrous metals at relatively shallow depths. Depth of detection depends on size and magnetic characteristics of object.
Seismic refraction	Measures propagation time for seismic (acoustic) waves refracted along subsurface contacts between materials of contrasting seismic velocity.	Delineate subsurface stratigraphy and structure.

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Unless otherwise noted, vadose zone borings will be drilled using either cable-tool or hollow-stem auger rigs. Samples will be taken continuously from the surface to a depth of 20 ft using a drive tube or split barrel sampler. Below the 20-ft depth, samples will be taken every 5 ft to the saturated zone (anticipated to be at a depth of approximately 50 to 60 ft at most locations). In the event of no sample recovery or inadequate sample, the boring will be cleaned out to the bottom of the sampling interval, and another sampling attempt will be made before advancing the hole to the next sampling depth.

To provide additional points at which to monitor groundwater levels in the 1100 Area, selected vadose zone holes that reach the groundwater may be completed as piezometers. The primary criteria for installation of a piezometer will be the need for water level data at that point. In highly contaminated areas, the possibility that the piezometer tube may constitute a pathway for contaminant migration directly to the groundwater will also be a consideration.

In addition to the vadose borings, additional composite samples will be obtained from near-surface soils by means of open-flight auger holes and hand-sampling methods.

Groundwater monitoring wells will be drilled with cable tool rigs. Other drilling methods may be used if rigs are available. For most sites in the 1100 Area, the maximum depth of groundwater monitoring wells is anticipated to be approximately 80 to 100 ft (the probable depth of the silt unit of the Ringold Formation), unless otherwise noted in the site-specific discussions below. Geologic samples will be obtained at 5-ft intervals and at significant changes in lithology. Aquifer tests will be conducted to support hydrogeologic characterization.

Groundwater samples will be collected from groundwater monitoring wells and existing wells in the 1100 Area on at least a quarterly basis for a minimum of 1 yr. Before sampling, the static water level will be measured and recorded.

Field quality control samples will also be collected. These will include trip blanks, field blanks, and duplicates or replicates. Field quality control samples are discussed in Section 5.0.

A preliminary summary of the vadose zone and groundwater sampling program for Phases 1A and 1B of the RI is presented in Table 4-5. The vadose and groundwater sampling program will be conducted in accordance with Westinghouse Hanford environmental investigation and site characterization procedures. A list of specific procedures and anticipated completion dates is given in Appendix C.

4.4.1.2 General Analytical Approach. In general, a broad-based analytical approach will be used to detect and identify contaminants. At present, no evidence of contaminants migrating from the 1100-EM-1 waste sites has been found. Because the waste disposal history at most of the sites is poorly documented, the initial analytical approach must consider a broad range of possible contaminants. Since the present conceptual model indicates that the groundwater pathway is the most credible, much of the analytical effort will be devoted to evaluating the quality of the groundwater in the unconfined aquifer. It will also be important to identify areas of contaminated soil from which contaminants may be percolating toward the groundwater.

Groundwater samples will fall into the following four broad categories:

- Well-development samples
- "Presumptive-indicator" samples
- Primary and secondary drinking-water-quality samples
- Groundwater samples for detailed characterization.

Table 4-5. Summary of Vadose Zone and Groundwater Characterization Program.

Activity	Battery acid pit (1100-1)	Disposal pits (1100-2 and 3)	Antifreeze tank(1100-4)	Radiation contamination site (1100-5)	Horn Rapids landfill	"Discolored-soil" site
RI Phase 1A						
Survey and establish grid	(10 ft)	(40 ft)	N/A	N/A	(100 ft)	N/A
Radiological survey	X	X	N/A	X	X	N/A
Ground-penetrating radar survey (ft line)	100	3,800	N/A	N/A	19,000	N/A
Electromagnetic survey	N/A	X	N/A	N/A	X	N/A
Magnetometer	N/A	N/A	N/A	N/A	X	N/A
Metal detector	N/A	X	N/A	N/A	X	N/A
Soil-gas survey	6	173	N/A	N/A	110	N/A
RI Phase 1B						
Near-surface soil samples	N/A	40	N/A	N/A	60	12
Vadose zone holes	2	9	N/A	N/A	10	N/A
Groundwater monitoring wells	2	4	1	N/A	8	N/A
Soil samples (total)	28	154	N/A	N/A	198	12
Physical analysis	10	45	N/A	N/A	50	N/A
Chemical analysis (soil)	14	93	N/A	N/A	50	12
Water sample analysis (quarterly)	3	4	1	N/A	10	N/A
Aquifer tests	1	3	N/A	N/A	6	N/A

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Field chemical analysis during well purging or development pumping is necessary to ensure that groundwater samples sent to the laboratory for more complete analysis are representative of formation conditions. Usually, a decision that well purging is reasonably complete is based on stabilization of a set of parameters that includes pH, temperature, specific conductance, and turbidity.

Presumptive indicator parameters are compounds likely to be associated with the presence of a contaminant plume. The choice of appropriate parameters is based on the waste-disposal history for each site and on the Washington Administrative Code, which specifies indicator parameters (Table 4-6).

Table 4-6. Indicator Parameters for Landfill.

A.	Temperature
B.	Conductivity
C.	pH
D.	Chloride
E.	Nitrate, nitrite, and ammonia as nitrogen
F.	Sulfate
G.	Dissolved iron
H.	Dissolved zinc and manganese
I.	Chemical oxygen demand
J.	Total organic carbon
K.	Total coliform

Source: WAC 173-304-490 (Ecology 1987b, p. 401).

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These parameters have been chosen for plume detection, but not necessarily to provide chemical characterization. In other words, when the indicator parameters fall outside specified ranges, it can be taken as an indication that the water is contaminated, but does not necessarily indicate the type and degree of contamination. Also, water may be chemically contaminated even when all indicator parameters are within acceptable limits.

In addition to the indicator parameters of Table 4-6, total organic halogen (TOX) should be included as an indicator parameter, since many of the suspected contaminants are halogenated solvents.

Confirmation that groundwater quality has or has not been affected by waste disposal must also be based on comparison to regulatory standards. Table 4-7 lists primary and secondary drinking-water standards.

Table 4-7. Primary and Secondary Drinking-Water Standards. (Sheet 1 of 2)

Primary drinking-water standards (40 CFR 141) (EPA 1986a)	
Inorganic compounds	**Maximum contaminant levels (mg/L)**
Arsenic	0.05
Barium	1.0
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.0
Selenium	0.01
Silver	0.05
Organic compounds	**Maximum contaminant levels (mg/L)**
Chlorinated hydrocarbons	
Endrin (1,2,3,4,10,-10-hexachloro-6,7-epoxy-1,4, 4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8-dimethano naphthalene)	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer)	
Methoxychlor (1,1,1-Trichloro-2, 2-bis [p-methoxyphenyl] ethane)	0.004
Toxaphene ($C_{10}H_{10}Cl_8$-Technical chlorinated camphene, 67-69% chlorine)	0.1
	0.005
Chlorophenoxys	
2,4-D (2,4-Dichlorophenoxyacetic acid)	
2,4,5-TP Silvex (2,4.5-Trichlorophenoxypropionic acid)	0.1
	0.01
Total trihalomethanes [the sum of the concentrations of bromodichloromethane, dibromochloromethane, tribromomethane (bromoform) and trichloromethane (chloroform)]	0.10 meq/L
Volatile organic compounds	**Maximum contaminant levels (mg/L)**
Benzene	0.005
Vinyl chloride	0.002
Carbon tetrachloride	0.005
1,2-Dichloroethane	0.005
Trichloroethylene	0.005
para-Dichlorobenzene	0.075
1,1-Dichloroethylene	0.007
1,1,1-Trichloroethane	0.2

Table 4-7. Primary and Secondary Drinking-Water Standards. (Sheet 2 of 2)

Primary drinking-water standards	
Radionuclides	Maximum contaminant levels
^{226}Ra and ^{228}Ra	5 pCi/L
Gross alpha	15 pCi/L
^{3}H (tritium)	20,000 pCi/L
^{90}Sr	8 pCi/L
Secondary drinking-water standards (40 CFR 143) (EPA 1987d)	
Contaminants	Maximum contaminant levels
Chloride	250 mg/L
Color	15 color units
Copper	1 mg/L
Corrosivity	Noncorrosive
Fluoride	2.0 mg/L
Foaming agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Sulfate	250 mg/L
Total dissolved solids	500 mg/L
Zinc	5 mg/L

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In addition to the above analyses, both groundwater and soil samples will be subjected to a suite of analyses designed to detect a broad range of possible contaminants. Analysis of soil and water samples will be conducted in accordance with laboratory procedures and protocols specified in the contract laboratory program (CLP) statements of work for organics and inorganics analyses (EPA 1988d, 1989). The scope of the initial analyses will be to detect and identify compounds on the CLP target compound list. This list is presented in Table 4-8.

As analytical data become available, it is anticipated that the scope of the analytical program can be narrowed to address primarily indicator compounds. An indicator compound will generally be a contaminant present near or above action levels established by the ARARs, for which it is anticipated that remedial action may be required or for which a risk assessment must be conducted. However, it is anticipated that most of the analytical samples collected in Phase 1B will be analyzed for the entire target compound list, with recommendations as to indicator compounds included in the Phase 1 RI report.

The soil-gas survey will be the primary means of detection for volatile organic compounds in soils. These compounds may be the result of disposal of solvents, degreasers, waste oil, gasoline, paint thinner, or other substances associated with vehicle maintenance operations.

Table 4-8. Target Compound List and Contract Required Quantitation Limits. (Sheet 1 of 6)

	Chemical abstract services number	Quantitation limits[a]	
		Water (µg/L)	Low soil/ sediment[b,c,d] (µg/kg)
Volatiles			
1. Chloromethane	74-87-3	10	10
2. Bromomethane	74-83-9	10	10
3. Vinyl chloride	75-01-4	10	10
4. Chloroethane	75-00-3	10	10
5. Methylene chloride	75-09-2	5	5
6. Acetone	67-64-1	10	10
7. Carbon disulfide	75-15-0	5	5
8. 1,1-dichloroethene	75-35-4	5	5
9. 1,1-dichloroethane	75-34-3	5	5
10. 1,2-dichloroethene (total)	540-59-0	5	5
11. Chloroform	67-66-3	5	5
12. 1,2-dichloroethane	107-06-2	5	5
13. 2-Butanone	78-93-3	10	10
14. 1,1,1-trichloroethane	71-55-6	5	5
15. Carbon tetrachloride	56-23-5	5	5
16. Vinyl acetate	108-05-4	10	10
17. Bromodichloromethane	75-27-4	5	5
18. 1,2-dichloropropane	78-87-5	5	5
19. cis-1,3-dichloropropene	10061-01-5	5	5
20. Trichloroethene	79-01-6	5	5
21. Dibromochloromethane	124-48-1	5	5
22. 1,1,2-trichloroethane	79-00-5	5	5
23. Benzene	71-43-2	5	5
24. trans-1,3-dichloropropene	10061-02-6	5	5
25. Bromoform	75-25-2	5	5
26. 4-methyl-2-pentanone	108-10-1	10	10

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Table 4-8. Target Compound List and Contract Required Quantitation Limits. (Sheet 2 of 6)

	Chemical abstract services number	Quantitation limits[a]	
		Water (µg/L)	Low soil/ sediment[b] (µg/kg)
Volatiles (cont.)			
27. 2-hexanone	591-78-6	10	10
28. Tetrachloroethene	127-18-4	5	5
29. Toluene	108-88-3	5	5
30. 1,1,2,2-tetrachloroethane	79-34-5	5	5
31. Chlorobenzene	108-90-7	5	5
32. Ethyl benzene	100-41-4	5	5
33. Styrene	100-42-5	5	5
34. Xylenes (total)	1330-20-7	5	5
Semivolatiles			
35. Phenol	108-95-2	10	330
36. bis (2-chloroethyl) ether	111-44-4	10	330
37. 2-chlorophenol	95-57-8	10	330
38. 1,3-dichlorobenzene	541-73-1	10	330
39. 1,4-dichlorobenzene	106-46-7	10	330
40. Benzyl alcohol	100-51-6	10	330
41. 1,2-dichlorobenzene	95-50-1	10	330
42. 2-methylphenol	95-48-7	10	330
43. bis (2-chloroisopropyl) ether	108-60-1	10	330
44. 4-methylphenol	106-44-5	10	330
45. N-nitroso-di-n-dipropylamine	621-64-7	10	330
46. Hexachloroethane	67-72-1	10	330
47. Nitrobenzene	98-95-3	10	330
48. Isophorone	78-59-1	10	330
49. 2-nitrophenol	88-75-5	10	330
50. 2,4-dimethylphenol	105-67-9	10	330
51. Benzoic acid	65-85-0	50	1,600
52. bis (2-chloroethoxy) methane	111-91-1	10	330

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Table 4-8. Target Compound List and Contract Required Quantitation Limits. (Sheet 3 of 6)

	Chemical abstract services number	Quantitation limits[a]	
		Water (µg/L)	Low soil/ sediment[b, c, d] (µg/kg)
Semivolatiles (cont.)			
53. 2,4-dichlorophenol	120-83-2	10	330
54. 1,2,4-trichlorobenzene	120-82-1	10	330
55. Naphthalene	91-20-3	10	330
56. 4-chloroaniline	106-47-8	10	330
57. Hexachlorobutadiene	87-68-3	10	330
58. 4-chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
59. 2-methylnaphthalene	91-57-6	10	330
60. Hexachlorocyclopentadiene	77-47-4	10	330
61. 2,4,6-trichlorophenol	88-06-2	10	330
62. 2,4,5-trichlorophenol	95-95-4	50	1,600
63. 2-chloronaphthalene	91-58-7	10	330
64. 2-nitroaniline	88-74-4	50	1,600
65. Dimethylphthalate	131-11-3	10	330
66. Acenaphthylene	208-96-8	10	330
67. 2,6-dinitrotoluene	606-20-2	10	330
68. 3-nitroaniline	99-09-2	50	1,600
69. Acenaphthene	83-32-9	10	330
70. 2,4-dinitrophenol	51-28-5	50	1,600
71. 4-nitrophenol	100-02-7	50	1,600
72. Dibenzofuran	132-64-9	10	330
73. 2,4-dinitrotoluene	121-14-2	10	330
74. Diethylphthalate	84-66-2	10	330
75. 4-chlorophenyl-phenyl ether	7005-72-3	10	330
76. Fluorene	86-73-7	10	330
77. 4-nitroaniline	100-01-6	50	1,600
78. 4,6-dinitro-2-methylphenol	534-52-1	50	1,600

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Table 4-8. Target Compound List and Contract Required Quantitation Limits. (Sheet 4 of 6)

	Chemical abstract services number	Quantitation limits[a]	
		Water (μg/L)	Low soil/ sediment[c, d] (μg/kg)
Semivolatiles (cont.)			
79. N-nitrosodiphenylamine	86-30-6	10	330
80. 4-bromophenyl-phenylether	101-55-3	10	330
81. Hexachlorobenzene	118-74-1	10	330
82. Pentachlorophenol	87-86-5	50	1,600
83. Phenanthrene	85-01-8	10	330
84. Anthracene	120-12-7	10	330
85. Di-n-butylphthalate	84-74-2	10	330
86. Fluoranthene	206-44-0	10	330
87. Pyrene	129-00-0	10	330
88. Butylbenzylphthalate	85-68-7	10	330
89. 3,3'-dichlorobenzidine	91-94-1	20	660
90. Benzo(a)anthracene	56-55-3	10	330
91. Chrysene	218-01-9	10	330
92. bis(2-ethylhexyl)phthalate	117-81-7	10	330
93. Di-n-octylphthalate	117-84-0	10	330
94. Benzo(b)fluoranthene	205-99-2	10	330
95. Benzo(k)fluoranthene	207-08-9	10	330
96. Benzo(a)pyrene	50-32-8	10	330
97. Indeno(1,2,3-cd)pyrene	193-39-5	10	330
98. Dibenz(a,h)anthracene	53-70-3	10	330
99. Benzo(g,h,i)perylene	191-24-2	10	330
Pesticides/polychlorinated biphenyls			
100. alpha-BHC	319-84-6	0.05	8.0
101. beta-BHC	319-85-7	0.05	8.0
102. delta-BHC	319-86-8	0.05	8.0
103. gamma-BHC (lindane)	58-89-9	0.05	8.0
104. Heptachlor	76-44-8	0.05	8.0

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Table 4-8. Target Compound List and Contract Required Quantitation Limits. (Sheet 5 of 6)

	Chemical abstract services number	Quantitation limits[a]	
		Water (μg/L)	Low soil/ sediment[b,c,d] (μg/kg)
Pesticides/polychlorinated biphenyls (cont.)			
105. Aldrin	309-00-2	0.05	8.0
106. Heptachlor epoxide	1024-57-3	0.05	8.0
107. Endosulfan I	959-98-8	0.05	8.0
108. Dieldrin	60-57-1	0.10	16.0
109. 4,4'-DDE	72-55-9	0.10	16.0
110. Endrin	72-20-8	0.10	16.0
111. Endosulfan II	33213-65-9	0.10	16.0
112. 4,4'-DDD	72-54-8	0.10	16.0
113. Endosulfan sulfate	1031-07-8	0.10	16.0
114. 4,4'-DDT	50-29-3	0.10	16.0
115. Methoxychlor	72-43-5	0.5	80.0
116. Endrin ketone	53494-70-5	0.10	16.0
117. alpha-chlordane	5103-71-9	0.5	80.0
118. gamma-chlordane	5103-74-2	0.5	80.0
119. Toxaphene	8001-35-2	1.0	160.0
120. Aroclor-1016	12674-11-2	0.5	80.0
121. Aroclor-1221	11104-28-2	0.5	80.0
122. Aroclor-1232	11141-16-5	0.5	80.0
123. Aroclor-1242	53469-21-9	0.5	80.0
124. Aroclor-1248	12672-29-6	0.5	80.0
125. Aroclor-1254	11097-69-1	1.0	160.0
126. Aroclor-1260	11096-82-5	1.0	160.0

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Table 4-8. Target Compound List and Contract Required Quantitation Limits. (Sheet 6 of 6)

Analyte	Contract-required detection limit (µg/L)
Inorganic target analyte list	
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5,000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5,000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5,000
Selenium	5
Silver	10
Sodium	5,000
Thallium	10
Vanadium	50
Zinc	20
Cyanide	10

NOTE: Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[a]Quantitation limits listed for soil/sediment are based on wet weight and concentration in extractant. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

[b]Medium soil/sediment contract-required quantitation limits (CRQL) for volatile target compound list compounds are 125 times the individual low soil/sediment CRQL.

[c]Medium soil/sediment CRQLs for semivolatile target compound list compounds are 60 times the individual low soil/sediment CRQL.

[d]Medium soil/sediment CRQLs for pesticide/polychlorinated biphenyls target compound list compounds are 15 times the individual low soil/sediment CRQL.

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Soil samples from vadose zone holes and near-surface soil samples obtained using hand-sampling techniques or open-flight auger rigs will be analyzed to detect organic and inorganic compounds. Selected soil samples may also be subjected to the extraction procedure or toxicity-characteristic leaching procedure; the resulting extractant will be analyzed to detect a wide range of contaminants.

Groundwater samples will be subject to analysis for indicator parameters (Table 4-6), compounds for which drinking water standards exist (Table 4-7), and compounds on the target compound list (Table 4-8).

In addition to the chemical analyses discussed above, soil samples will also be tested for physical properties pertinent to characterization and evaluation of remedial alternatives. Physical properties of interest during the initial RI include particle size gradation and moisture content. Specific test procedures for physical properties are indicated on Table 4-9.

Table 4-9. Physical Tests for Soil Samples.

Physical test	Location
"Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)"	Annual Book of ASTM Standards, Vol. 4.08, ASTM D2488 (ASTM 1986b).
"Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures"	Annual Book of ASTM Standards, Vol. 4.08, ASTM D2216 (ASTM 1986a).
"Bulk Density"	Methods of Soil Analysis, Part 1 (American Society of Agronomy 1986a).
"Water Retention: Laboratory Methods"	Methods of Soil Analysis, Part 1 (American Society of Agronomy 1986c).
"Hydraulic Conductivity and Diffusivity: Laboratory Methods"	Methods of Soil Analysis, Part 1(American Society of Agronomy 1986b).
"Cation Exchange Capacity"	Methods of Soil Analysis, Part 2 (American Society of Agronomy 1982).
"Particle Size Analysis of Soils"	Annual Book of ASTM standards, Vol. 4.08, ASTM D422 (ASTM 1986c).

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Aquifer testing (including slug tests and constant discharge pumping tests) will be conducted to estimate in situ aquifer properties required for contaminant transport modeling. Aquifer tests will be carried out in accordance with aquifer test procedures included in the Westinghouse Hanford environmental investigation and site characterization procedures (see Appendix C).

In terms of location and site characteristics, the 1100-EM-1 waste sites can be subdivided into four groups. The specific sampling and analysis program for each group of sites will be discussed below.

4.4.1.3 Battery Acid Pit (1100-1) and Antifreeze Tank (1100-4). The battery acid pit and the antifreeze tank are both located in the vicinity of the 1171 Building, which is the vehicle maintenance facility for the Hanford Site. Since they are relatively close together, they will be combined for the purposes of the vadose zone and groundwater investigation program. Contaminants of concern in this area are compounds associated with routine vehicle maintenance operations. Materials known to have been disposed to the soil column are sulfuric acid (containing lead and cadmium compounds) and ethylene glycol. Other compounds that may have been disposed include solvents, gasoline, waste engine and hydraulic oil (possibly containing PCBs), and degreasers.

The primary objective of the vadose and groundwater investigation program in the vicinity of the 1171 Building is to detect and identify any contaminants in the vadose zone or unconfined aquifer, to determine site stratigraphy and soil characteristics, and to determine the groundwater flow gradient and permeability of the unconfined aquifer. This will provide data for preliminary risk assessment and identification of appropriate remedial technologies. Additional site characterization work may be required later, depending on the nature of the contamination hazard and the requirements of the remedial technologies under consideration.

During the approximate period of 1954 to 1977, spent battery acid was discharged into an unlined pit (i.e., dry sump or French drain) located near the southwest corner of the 1171 Building. The area slopes very slightly toward the west and south along the railroad tracks, which are approximately 50 ft to the west. The exact location and size of the pit is not known, although estimates by motor-pool workers range from 5 to 12 ft in diameter and 5 to 10 ft deep. The pit was reportedly located approximately 15 ft south of the emergency shower.

A total of 15,000 gal of battery acid are estimated to have been dumped into the pit, based on extrapolation of present vehicle fleet usage rates. This is likely to be relatively conservative (high), because it assumes a constant fleet size of 2,000 vehicles over a 24-yr period and assumes that all of the spent battery acid was dumped into the pit. Although battery acid is the only substance known to have been dumped into the pit, the proximity to vehicle maintenance operations suggests that other contaminants may have also been dumped into the pit, but no record of such disposal exists. Two surface soil samples obtained from the vicinity of the battery acid pit in March 1988 were found to contain elevated levels of lead, but this result is of questionable value, because the pit is known to have been backfilled. The elevated lead levels may be due to proximity to a vehicle maintenance area where leaded gas has been used in the past. The results of these analyses are discussed further in Appendix B.

Until 1986, waste antifreeze was discharged to a 5,000-gal holding tank under the northeast corner of the 1171 Building. This tank was taken out of service and removed in 1986. It is suspected of having leaked. However, soil samples taken at the time the tank was exhumed did not contain detectable levels of ethylene glycol.

Ground surface elevation in the vicinity of the 1171 Building is approximately 400 ft above sea level. Geologic conditions are not well known. As indicated on Figure 4-5, the strata underlying the 1100 Area above the basalt include the Pasco gravels of the Hanford formation and the Ringold Formation. Figure 4-7 shows the driller's log for well 3000-D-1 (1199-S41-13C), which is located approximately 3,000 ft to the north-northeast. This log suggests that the upper 5 ft is sand, with gravel and sandy gravel present to a depth of approximately 85 ft (elevation approximately 320 ft above sea level), where brown silt or clay is encountered. This silt/clay layer in the Ringold Formation may be laterally extensive and (where present) probably acts as an aquiclude, defining the lower boundary of the unconfined aquifer. The groundwater level in the unconfined aquifer is at a depth of approximately 50 ft.

The only credible transport mechanism for contaminants is percolation through the soil column to the groundwater in the unconfined aquifer. The public water supply wells located in the north Richland well field (approximately 1/2 mi to the east) and the Duke well field (approximately 3/4 mi to the southeast) are the most credible receptors. Although local groundwater flow conditions are not known, the regional gradient is west to east. Therefore it is assumed for the present that the direction of groundwater travel is toward the north Richland well field.

No soil samples or geophysical surveys are planned in the vicinity of the antifreeze tank. A soil sampling effort may be required later if ethylene glycol is detected in water samples from well MW-3, or if further evaluation of the samples taken at the time the tank was removed indicate that a higher level of data quality is required. If necessary, additional samples can be taken by drilling through the concrete floor.

Figure 4-8 shows the location of geophysical traverses, soil-gas points, and vadose zone holes in the vicinity of the battery acid pit. Geophysical traverses using ground-penetrating radar will be conducted first to locate the pit.

Once the pit has been located, a limited soil-gas survey will be conducted. The purpose of the soil-gas measurements is to detect and identify any volatile organic vapors present in the near surface. This will provide some indication as to whether other substances such as solvents, gasoline, etc., were disposed of in or near the battery acid pit.

One vadose zone hole (BAP-1) will be drilled at the center of the pit, as indicated by geophysical survey data and visual evidence. The hole will be sampled continuously to a depth of 20 ft. Of the 10 samples collected, at least five will be submitted for chemical analysis using CLP protocols (analytical Level IV). In general, alternate samples will be submitted for chemical analysis. However, any sample that shows evidence of contamination

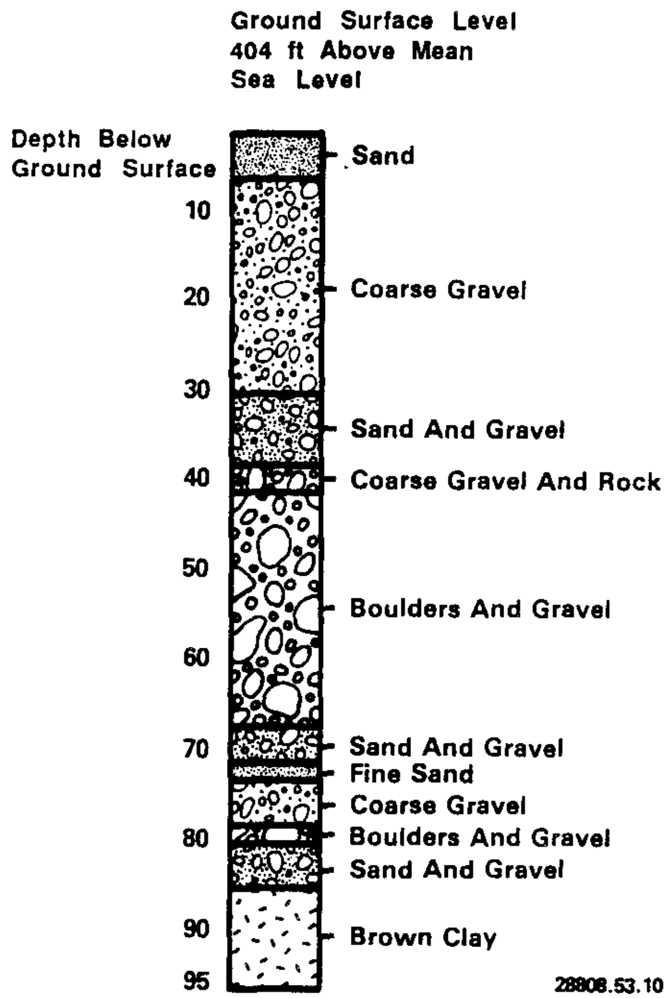


Figure 4-7. Driller's Log for Well 1199-S41-13C (3000-D-1).

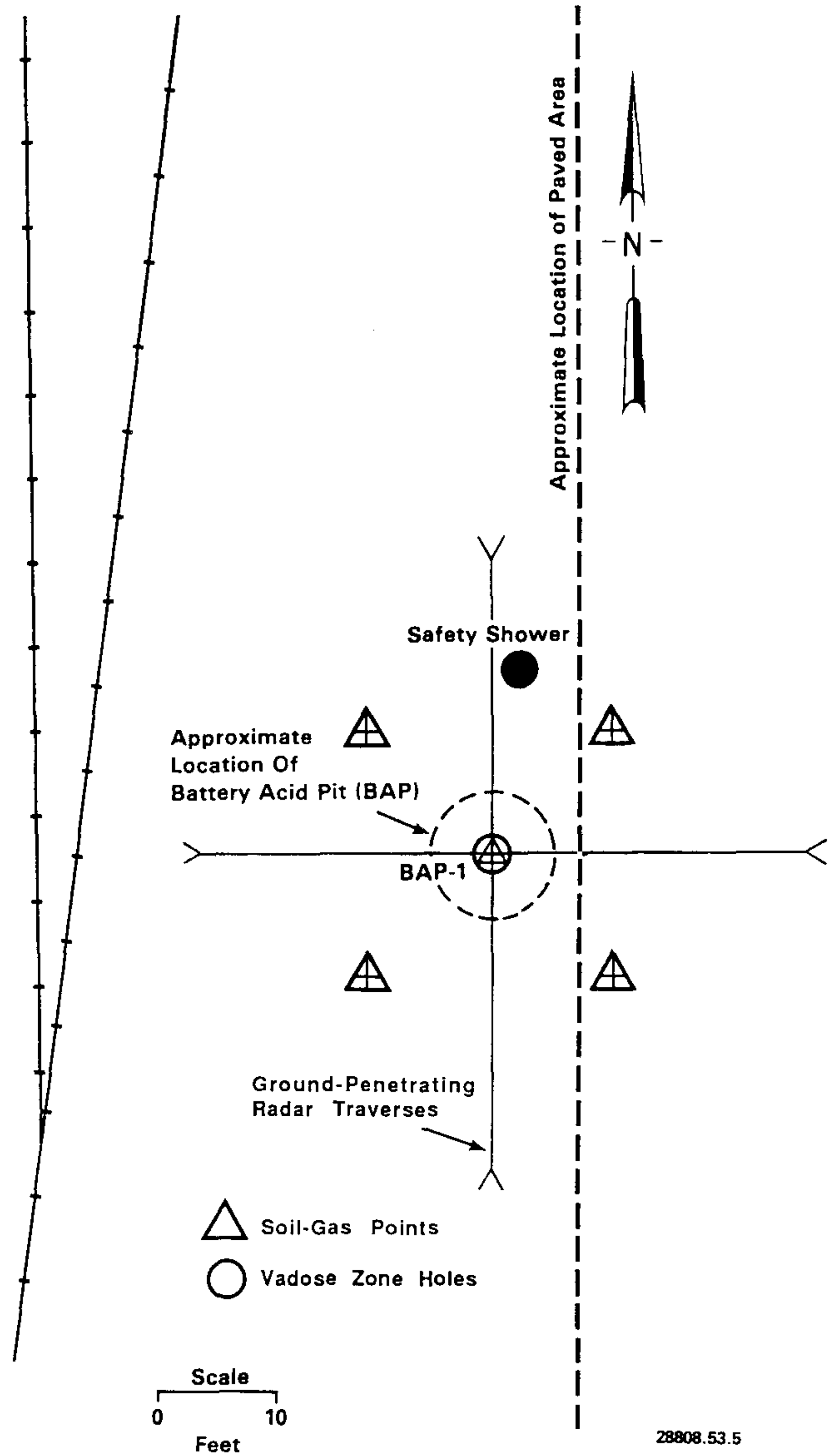


Figure 4-8. Vadose Zone Sampling Plan for the Battery Acid Pit.

(e.g., discoloration, oily or greasy, etc.) will be submitted for chemical analysis. The remaining five samples will be submitted for analysis of particle size gradation and moisture content.

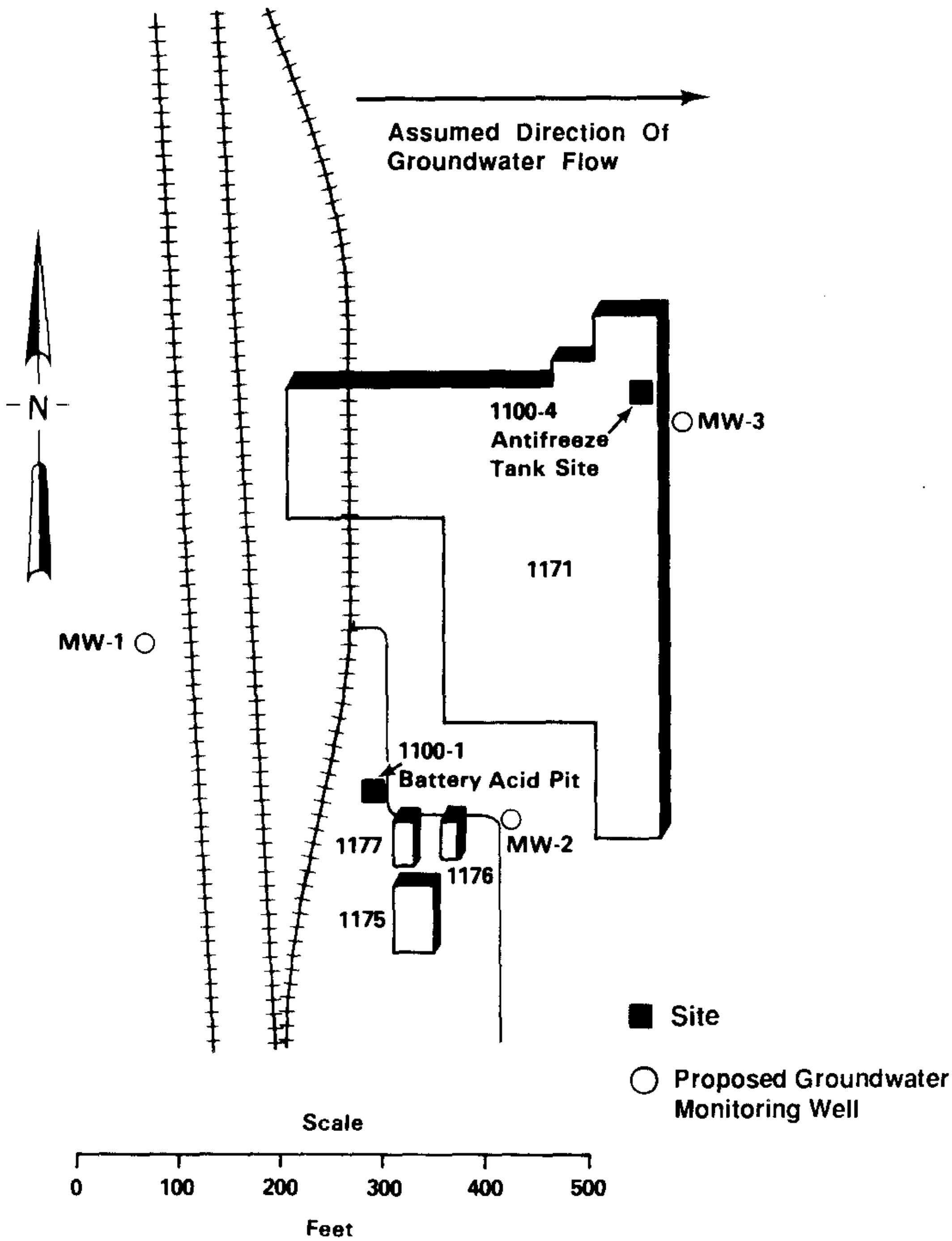
A second vadose zone hole (BAP-2) will be drilled in an area west of the railroad tracks. The purpose of this hole is to provide samples to establish background levels. The hole will be drilled to the groundwater (approximately 25 ft) with samples taken continuously in the upper 20 ft and at 5-ft intervals for the remainder of the hole. Additional samples will be taken at any change in lithology. At least five samples from the upper 20-ft interval will be submitted for chemical analysis. Below 20 ft, at least one sample from each lithologic unit encountered will be submitted for chemical analysis. At least five samples will be submitted for analysis of particle size gradation and moisture content.

In the event that the proportion of cobbles and boulders is too great for adequate sample recovery from boreholes, consideration will be given to digging a test pit with a backhoe. Representative samples will be obtained from the backhoe bucket to avoid personnel access into potentially unstable pits. Although backhoe pits are limited to a maximum depth of approximately 15 ft, this should be adequate to determine the presence of contamination in the vadose zone.

Soil samples will be classified in the field in accordance with Westinghouse Hanford geologic logging procedures (see Appendix C). Natural moisture content will be noted and calcium carbonate content will be estimated by noting the reaction to dilute hydrochloric acid.

The primary contaminants of concern at the battery acid pit are lead and cadmium. Data required to support preliminary risk assessment include concentration and extent of contamination as well as mobility of the lead and cadmium compounds under in situ conditions. Therefore, chemical analyses of soil samples will be oriented toward determination of lead and cadmium values, although the analytical effort will include testing for other inorganic and organic compounds on the target compound list.

Three monitoring wells will be installed in the vicinity of the 1171 Building. The locations of these wells are shown on Figure 4-9. They are located so as to obtain a measurement of water level at three noncolinear points and to obtain samples downgradient of each waste site as well as upgradient. These wells will be drilled using cable-tool, rotary, or rotary-percussion equipment. Since the 1171 Building is an operating vehicle-maintenance facility, some consideration must be given to interference with operations. For example, a monitoring well located in the middle of a roadway will restrict or impede traffic flow, and will likely be subject to damage from vehicular traffic. Given the lack of precise data regarding aquifer properties and groundwater flow direction or travel time, it is impossible to make any reliable statements regarding probable plume location at this time. Placement of wells in areas where they will minimize interference with facility operations will be considered to the extent that it is practical. However, in all cases wells shall be placed in locations suitable to meet the intent of the investigation.



Note: Locations shown are approximate

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Figure 4-9. Monitoring Well Locations.

Two monitoring wells will be installed in the vicinity of the battery acid pit. The first well (MW-1) will be located about 230 ft to the west-northwest of the battery acid pit. The primary justification for this distance is access: the presence of active railroad lines precludes a closer location. This well will serve as an upgradient background location for groundwater samples. It will be completed with the screen installed in the unconfined aquifer (estimated maximum depth of 80 to 90 ft). Samples will be obtained using a split barrel or drive tube sampler at 5-ft intervals. Additional samples will be taken at each strata change. Representative samples from each strata will be submitted for physical properties tests.

The second well, MW-2, will be located approximately 130 ft to the east of the battery acid pit. The location of this well is also constrained by access considerations: the final location will be chosen to minimize interference with operations, while remaining outside of and downgradient from the zone of probable vadose contamination. The well will be located consistent with the regional gradient and between the battery acid pit (source) and the north Richland well field (receptor). Well MW-2 will be completed in the unconfined aquifer.

A third groundwater monitoring well, MW-3, will be located east of the antifreeze tank site (1100-4). This well will also be located so as to minimize interference with operations. It is intended to intercept any contaminant plume moving from the antifreeze tank site in the direction of the north Richland well field. Well MW-3 will be drilled to the silt/clay layer (anticipated depth of 80 to 90 ft, see Fig. 4-7) and completed in the unconfined aquifer. Although vadose zone samples will be obtained for geologic characterization, they will not be analyzed for contaminants because the well is too far from the tank location. Water samples will be collected and analyzed for ethylene glycol by gas chromatography (direct aqueous injection), in addition to the CLP analyses.

The three wells in the vicinity of the 1171 Building are located in such a way that water-level measurements can be combined to obtain an indication of the groundwater flow direction and gradient in the vicinity of the 1171 Building.

The completion details for the groundwater-monitoring wells will depend on conditions encountered. Based on the driller's log for well 3000-D-1 (Fig. 4-7), the depth to the water table is approximately 55 ft, and the unconfined aquifer appears to have a saturated thickness on the order of 30 ft. For this situation, a screened interval of 20 ft is proposed, with at least 15 ft set below the static water level. A screen length of 15 ft within the aquifer will allow for large fluctuations in water level. However, the final screen length and screen set depth will be adjusted as appropriate to accommodate local hydrogeologic conditions encountered in the well.

4.4.1.4 Radiation Contamination Incident (1100-5). This is the location of a minor radiation contamination incident in which contamination was discovered on an incoming 16-ton cask and truck trailer when it arrived at the 1100 Area receiving facility in 1962. At the time the contamination was discovered the trailer was parked "in the parking lot northwest of the 1171 Building." The radiation incident report notes that the leaking water had wet an area of approximately 1-ft dia on the trailer bed. Contamination was also noted on the underside of the trailer bed. No mention is made of ground surface contamination in the 1100 Area. Hanford Site policy at the time was (and is) that no site would be unconditionally released if any contamination were present. Therefore, the probability that a significant area of surface contamination in the 1100 Area went unnoticed is considered remote.

There is no evidence to suggest that any quantity of contaminated water was discharged. The possibility of migration of radionuclides to the unconfined aquifer is considered to be nil. A vehicle-mounted radiological survey of the parking lot did not detect any areas of surface contamination. Therefore, no further work is planned at this site.

4.4.1.5 Disposal Pits (1100-2, 1100-3 and UN-1100-6). These sites are considered together because of similar characteristics. Each represents the location where liquid wastes may have been disposed of by dumping on the ground surface. At 1100-2 and 1100-3 there is a possibility of buried drums, but this is not considered likely. Each site is thought to consist of localized areas from which contaminants may have percolated down to the unconfined aquifer.

The "paint and solvent pit" (1100-2) and "antifreeze and degreaser pit" (1100-3) are located in close proximity and have generally similar characteristics. Hence, they will be discussed in terms of a single conceptual model, with any significant differences in the two sites noted. The relative locations of the two pits are shown in Figures 2-1 and 4-3.

The "paint and solvent pit" (1100-2) is reported to have received irregular disposal of paints, paint thinners, and solvents in addition to miscellaneous construction waste from 1954 to 1985. The pit is an elongated shape approximately 250 ft long, 100 ft wide, and 5 to 6 ft deep, which lies along the east side of the railroad tracks. A dirt road runs along the base of the railroad ballast, enters the pit on the southwest, and crosses to the north, where it emerges from the pit and joins a dirt road that generally follows an old railroad alignment parallel to Stevens Drive east of the pit. The pit is located approximately 300 ft west of Stevens Drive. There is no visible evidence of paint, solvent, or discolored soil on the surface in the vicinity of this site. The exact locations of paint and solvent disposal at this site are unknown. No chemical inventory is available. Analyses of two surface soil samples obtained in March 1988 reveal no evidence of contamination. A conservative estimate of the volume of paint thinner and other solvents disposed of in the pit is estimated to be a maximum of 100 gal/yr, or approximately 3,000 gal over the 30-yr history of the pit.

The "antifreeze and degreaser pit" (1100-3) is reported to have received irregular disposal of antifreeze and degreasing solvents from 1979 to 1985. It is an approximately circular depression about 250 ft in diameter and 8 to

12 ft deep. Access to the pit is by means of a dirt road that enters from the southwest. It is reported to have been an excavation for sand and gravel borrow material, with the bottom of the original pit at roughly the present observed depth. Approximately 30 yd^3 of used roofing gravel and 1 yd^3 of concrete rubble lie in piles dumped on the relatively level bottom of the borrow pit. The quantity of antifreeze and degreasers, as well as specific disposal locations within the pit, are unknown. No chemical inventory is available, but analysis of two surface soil samples taken in March 1988 revealed no evidence of contamination.

Waste dumped in either pit was probably hauled from the vicinity of the 1171 Building and dumped on the ground. Therefore, the most likely areas for waste disposal are in the vicinity of access points. For either pit, the southwest corner is the most likely spot. For the 1100-2 pit, dumping on either side of the railroad tracks is possible. Disposal would also be likely along the northeast side of the pit, because of proximity to Stevens Drive.

Liquid dumped on the ground at either site would generally tend to flow along the surface toward the center of the pit, and percolate into the soil quickly. During periods of heavy precipitation, water may tend to pond in the pits, picking up contaminants from the soil and carrying them downward to the groundwater.

Geologic conditions appear to be similar at each site. Well 3000-D-1 (Fig. 4-7) is located approximately 700 to 800 ft to the south-southeast. The log suggests that the upper 5 ft is sand, with gravel and sandy gravel present to a depth of approximately 85 ft (elevation approximately 320 ft above sea level), where brown silt or clay is encountered. This silt/clay layer in the Ringold Formation appears to be laterally extensive and probably acts as an aquiclude, defining the lower boundary of the unconfined aquifer. The groundwater level in the unconfined aquifer is at a depth of approximately 50 ft. The north Richland well field is located to the east-southeast, and groundwater movement may be in this general direction.

In the course of the site inspection activities at the 1100-EM-1 operable unit waste sites, an additional potential waste site was found. This site is a patch of oily, discolored soil in an elongated natural depression adjacent to the railroad tracks northwest of the 1171 Building. A grab sample of surface soils was taken from this site and found to contain measurable concentrations of two phthalates, nine unknown acid-base neutral constituents, and elevated TOC. Hence, this site has been designated as the "discolored-soil" site and will be investigated further. This site appears to be the location of a least one, and possibly several, incidents where drums of liquid material were dumped on the ground. The depression in which the spill is located would tend to collect and contain any surface water during periods of heavy precipitation. Given the relatively small volume of fluid involved, much of the contamination will likely remain in the upper few feet of soil, unless additional water is available to flush the contaminants through the soil column.

The only credible transport mechanism for contaminants at each of these sites is percolation through the soil column to the groundwater in the unconfined aquifer. The public water supply wells located in the north Richland well field (approximately 1/2 mi to the east-southeast) are the most credible receptors. Although local groundwater flow conditions are not known, the regional gradient is west to east. Therefore, it is assumed for the present that the direction of groundwater travel is toward the north Richland well field.

Figure 4-10 shows the location of various survey lines and sampling points proposed for the 1100-2 and 1100-3 sites. Although no radioactive material is known to have been disposed of at either pit, a radiological survey was conducted using vehicle-mounted detectors as a routine precautionary measure. No evidence of radiological contamination was found.

At both of these sites a sampling grid with a 40-ft spacing has been established. The 40-ft grid spacing is based on approximate depth to the water table, taking into account the geometry and overall size of each pit. At 1100-2, the grid is oriented parallel to the railroad tracks. At 1100-3, the grid is established in a north-south orientation. Maps will be prepared, and each site will be carefully inspected by geologists and biologists. Geologic features, type and condition of vegetation, evidence of small mammals, soil discoloration, and other pertinent features will be noted and located in relation to the sampling grid.

Geophysical surveys have been conducted along grid lines. The geophysical surveys consisted of ground-penetrating radar, metal detection, and electromagnetic (conductivity) measurements. Geophysical surveys were extended beyond the boundaries of each site as necessary to delineate anomalies. The purpose of these techniques is to determine the depth of fill at the site, to locate original boundaries of the excavations, to detect the presence of buried objects, and to detect anomalies that may be associated with the presence of contaminants.

After the geophysical surveys are completed, a soil-gas survey was conducted, with samples taken at each node of the sampling grid. At the time of this writing, the soil-gas survey had been completed at 1100-2 but not yet started at 1100-3. No data are available yet. The purpose of the soil-gas survey is to detect and identify any organic vapors associated with the presence of volatile organic compounds in the soil or groundwater. The soil-gas survey may be extended beyond the boundaries of each site as necessary to define the margins of any vapor plumes. Additional soil-gas measurements may be made at intermediate points to "fill in" as required.

After the geophysical and soil-gas surveys are completed (Phase 1A), the data will be evaluated, and Phase 1B sampling locations will be finalized.

Near-surface soil samples will be obtained from approximately 20% of the grid nodes in each site. Sampling nodes will be chosen by random selection. These samples will be obtained using an open-flight auger rig capable of drilling to a depth of 10 ft. Physical characteristics such as soil type, grain size distribution, and color will be noted in the field. The sand/silt/clay fraction of these soil samples will be analyzed for contaminants on the target compound list in accordance with test procedures identified in the CLP statements of work (EPA 1988d, 1989). Approximately 20 near-surface soil samples will be obtained from each pit.

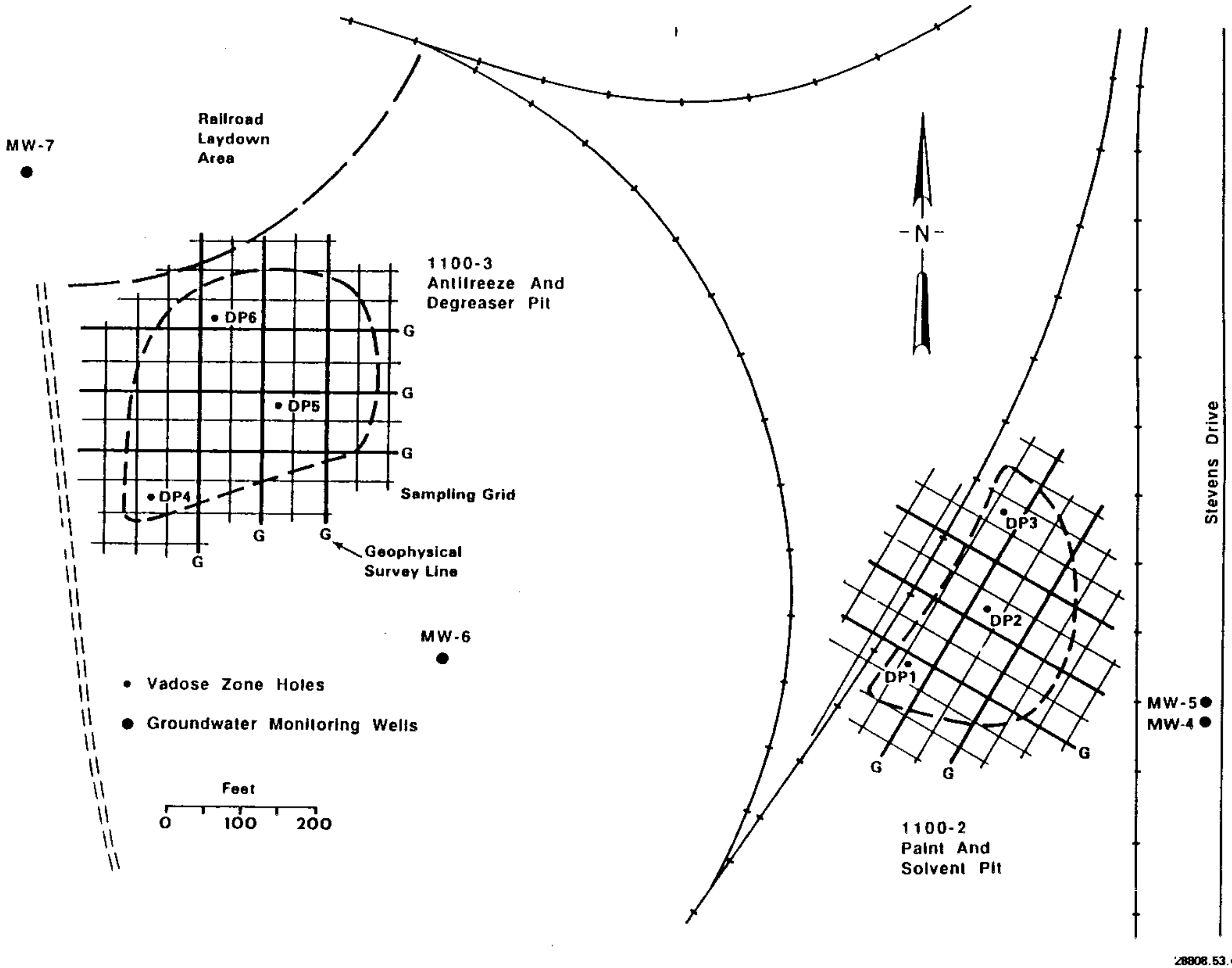

Figure 4-10. Vadose Zone Groundwater Sampling Plan for the Antifreeze and Degreaser Pit and the Paint and Solvent Pit.

Four vadose-zone holes are proposed for each of the sites. Three will be drilled to a mazimum depth of 20 ft. The fourth will be drilled to the saturated zone (approximately 55 ft). These holes will be drilled using a hollow-stem auger. Samples will be obtained continuously from 0 to 20 ft deep and at 5-ft intervals below 20 ft. The preliminary locations of the holes were chosen on the basis of the conceptual models for each site. Final locations will be dependent on the results of the geophysical and soil-gas surveys. Additional holes may be added if the geophysical and soil-gas data indicate a higher degree of complexity than expected. An additional vadose zone hole will be drilled in an undisturbed location to provide background data.

Physical analyses will also be conducted on selected samples from each strata to provide data to support preliminary identification of remedial alternatives. These may include particle size, moisture content, bulk density, water retention, hydraulic conductivity and diffusivity, and cation exchange capacity, as appropriate. Specific test procedures are indicated on Table 4-9. In each well or borehole, soil samples will be collected for analysis of physical properties at each major lithologic change.

Four groundwater-monitoring wells will be installed in the vicinity of these two waste sites. The purpose of these wells is hydrogeologic characterization of the unconfined aquifer and detection of any contaminants that may be present. Two wells, MW-4 and MW-5, will be located in the assumed downgradient direction from both pits. Well MW-4 will be completed with a screened interval in the upper part of the unconfined aquifer, and well MW-5 will be drilled to the silt layer in the Ringold Formation (approximately 85 ft depth) and will be completed with a screened interval in the lower part of the aquifer. Well MW-6 will be located upgradient of 1100-2 and downgradient of 1100-3. It will be completed in the upper part of the unconfined aquifer. Well MW-7 will be located upgradient of 1100-3 and will also be completed in the upper part of the aquifer. Well MW-6 will be drilled to the silt layer to determine the thickness of the unconfined aquifer. The wells will be located in such a way that water-level measurements in wells MW-4, MW-6, MW-7, and existing wells can be used to determine the general groundwater flow direction and gradient in the vicinity of the disposal pits. Water-level measurements will also be available from well 1199-S41-13C (3000-D-1) and from other wells in the vicinity. Samples will be collected and logged in accordance with Westinghouse Hanford geologic logging procedures to characterize the hydrogeologic units in the vicinity of the disposal pits. Additional monitoring wells may be considered after the initial phase of the RI is completed.

The discolored-soil site is assumed to be an area of surficial contamination resulting from surface disposal of the contents of one or more drums. The size of the discolored area suggests that a relatively small quantity of waste was involved and that significant percolation to the groundwater is not likely. The site will initially be investigated by means of hand-sampling tools. A sampling grid will be established with a 10-ft spacing. Samples will be obtained to a maximum depth of 5 ft, with a minimum of 10 randomly distributed sampling points. Of these, eight will be located toward the northeastern 25 percent of the depression where the discoloration exists, and the remaining two will be located toward the southwestern end. These samples will be analyzed for the full range of contaminants listed in the target compound list. If evidence of contamination is found, it will be necessary to obtain deeper samples by drilling one or more vadose zone holes.

4.4.1.6 Horn Rapids Landfill. The Horn Rapids landfill was operated as a solid-waste landfill from approximately 1950 to 1970. The site is reported to have received indeterminate quantities of hazardous chemicals (possibly in drums), tires, asbestos materials, construction debris, and scrap lumber. Evidence also exists of liquid disposal; probably sewage sludge and/or fly ash. It was apparently used by a variety of contractors, and unauthorized dumping by both onsite and offsite parties was reportedly a continuing problem. Two larger north-south trenches in the southwest quadrant of the site may have received drums of carbon tetrachloride and possibly other hazardous materials. The wastes were dumped from trucks into trenches, covered with dirt, and probably compacted to some degree by equipment operation.

Hanford Site personnel involved in operation of the landfill noted that standing water was frequently observed in the burial trenches, and that there were "springs" in the bottoms of the trenches. This indicates that wastes may be in, or very close to, the groundwater. This is consistent with the estimated depth to the water table and the estimated depth of the trenches (see Fig. 4-6). No liners or other barriers or covers were used, and no effort was made to divert water from the trenches.

Figure 4-11 shows the driller's log for a well drilled approximately 1 mi north of the Horn Rapids landfill. The driller's log provides a general indication of the geologic conditions likely to be encountered.

The primary transport mechanism of waste is infiltration or vapor-phase transport to the groundwater. Where wastes are in contact with the groundwater, contaminants may leach directly to groundwater. The groundwater flow direction in the vicinity of the Horn Rapids landfill is thought to be from west to east. Available water table data indicate easterly or northeasterly groundwater flow; however, perturbations to the water table from the operations in the 300 and 3000 Areas and possibly at Advanced Nuclear Fuels Corporation are likely.

While no radioactive material is known to have been disposed of in the Horn Rapids landfill, a radiological survey has been conducted as a precautionary measure using vehicle-mounted detectors. No surface radiological contamination was detected.

A sampling grid with a 100-ft spacing has been established. Additional intermediate grid points will be established as necessary for additional investigative work. The use of a closer spacing for the initial Phase 1A survey techniques over the entire area of the Horn Rapids landfill was rejected because of the size of the area to be investigated. The 100-ft spacing of the grid was chosen to minimize sampling points because transport of volatile wastes since last use of the landfill is expected to have spread contaminants over relatively large distances. Also, disposal areas are generally known; in these areas, supplemental grid lines can be added as

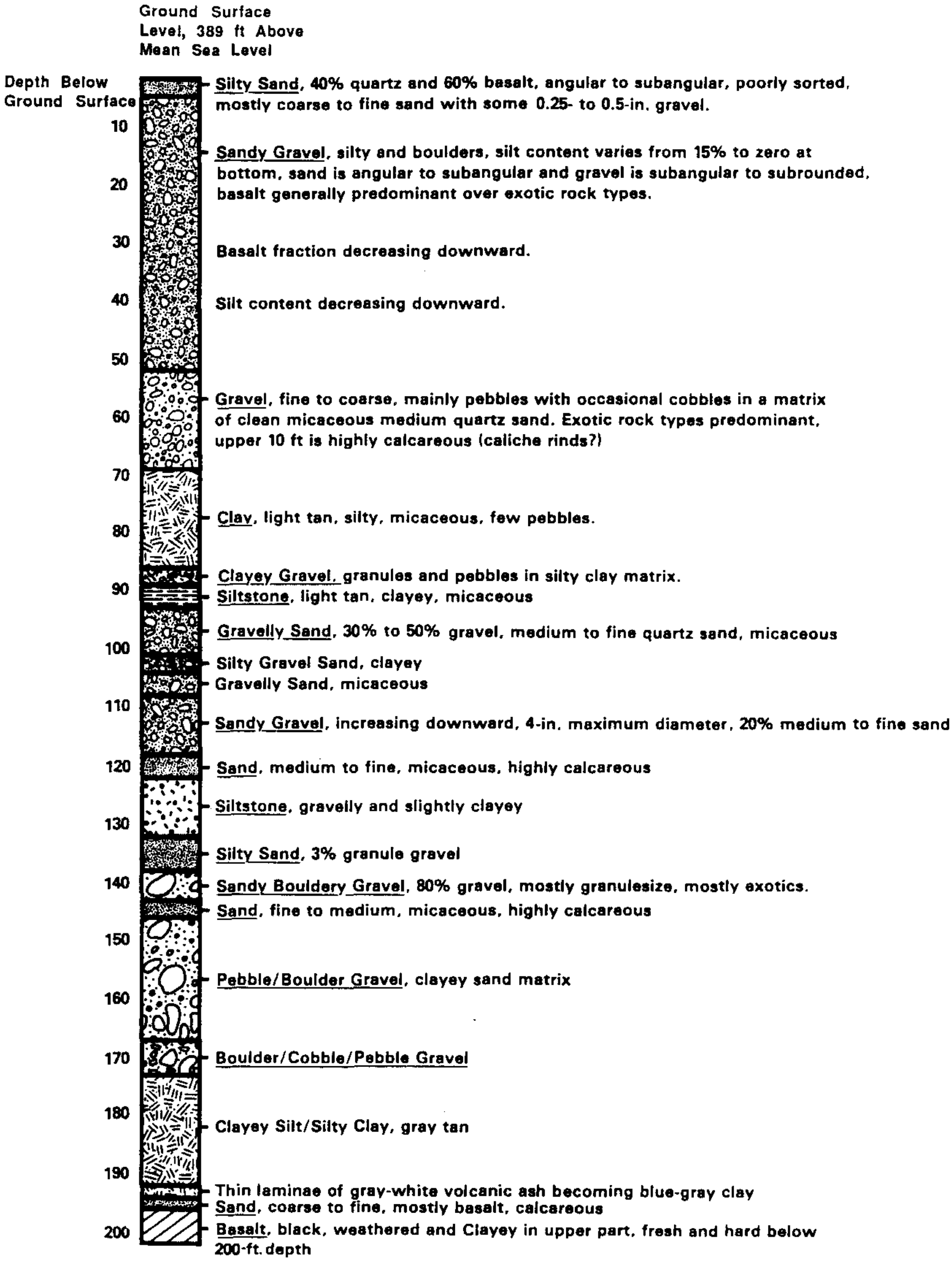

Figure 4-11. Driller's Log for Well 10/28-10G1.

necessary to provide more complete coverage. The spacing is also judged to be adequate for location of features identified by geologists and biologists and to provide adequate coverage by geophysical methods, supplemented by additional lines in known or suspected disposal areas. Detection of anomalies may also result in utilization of more closely spaced traverses and/or finer sampling grids to further define the anomalous features. These supplemental grids will be established in the field as necessary and referenced to the 100-ft grid.

Maps will be prepared and the site will be carefully inspected by geologists and biologists. Geologic features, type and condition of vegetation, evidence of small mammals, soil discoloration, and other pertinent features will be noted and located in relation to the sampling grid.

Ground-penetrating radar, metal detection, and electromagnetic measurements have been made along grid lines at the landfill. The data from these surveys will be used to determine the amount of fill over the site, to detect buried objects, to better define the boundaries of the landfill, and to delineate individual burial trenches.

A soil-gas survey is presently being conducted on the nodes of the sampling grid. The soil-gas data will be used to detect and identify organic vapors associated with volatile organic compounds in the soil or groundwater.

Phase 1B will be concerned primarily with vadose zone boreholes within the landfill and groundwater monitoring wells around the perimeter of the landfill. Additional near-surface soil samples will be obtained using hand-sampling methods or open flight auger rigs. The purpose of the vadose zone boreholes within the landfill is to define types of contaminants at or near their sources. On the other hand, the groundwater monitoring boreholes serve to detect contaminants that may have actually entered the groundwater and to define the groundwater flow directions and hydrologic properties.

Near-surface soil samples will be taken in areas of interest identified by the geologic or biological inspection of the area. If possible, hand-sampling methods will be used; however, it is anticipated that a powered open-flight auger rig may be needed due to the high proportion of gravel and boulders in the soil.

Preliminary sampling locations for the vadose zone holes and groundwater monitoring wells are shown in Figure 4-12. After the Phase 1A geophysical and soil-gas surveys are completed, the data will be evaluated, and the locations of near-surface soil samples, vadose zone holes, and groundwater monitoring wells will be finalized. In the event that drums or other forms of waste containers are detected by geophysical surveys, sampling points will be relocated to avoid penetrating these objects. It is anticipated that any buried waste containers will have to be exhumed for sampling of contents and possible removal. The specific approach to be used will be dependent on the circumstances of burial and the geologic conditions.

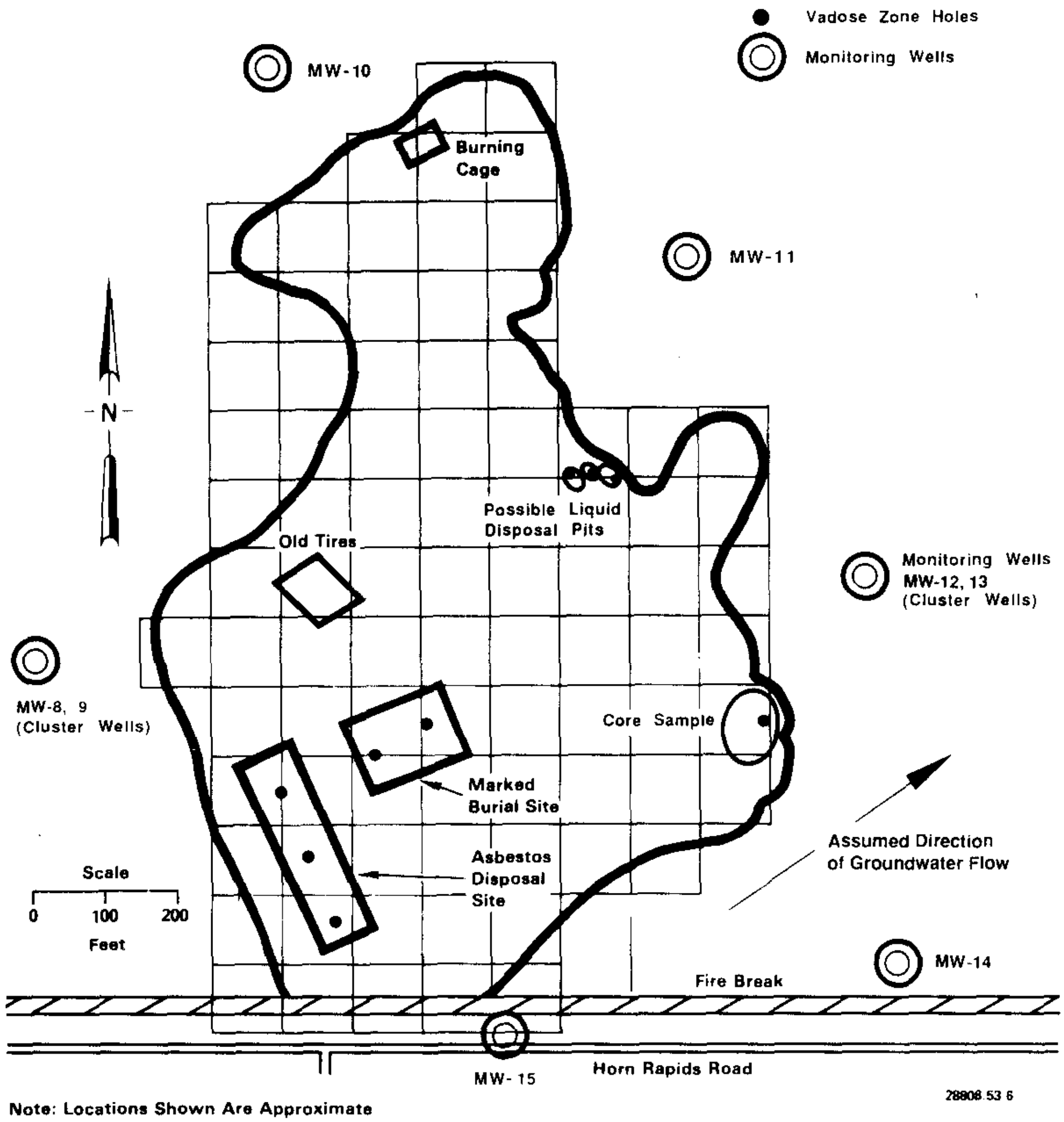

Figure 4-12. Horn Rapids Landfill Preliminary Sampling Locations.

Based on existing knowledge of the landfill, nine vadose zone holes are tentatively proposed at four separate locations in the landfill. Final locations of vadose-zone holes and monitoring wells to be drilled in Phase 1B will be determined only after careful examination of Phase 1A data. Preliminary identification of specific borehole locations described below was based on reasonable spatial coverage of each known or suspected disposal area that could serve as a source of specific contaminants. A tenth vadose zone hole wil be drilled in an undisturbed area west of the Horn Rapids landfill to provide background data.

The first location is a landfill cell marked as an asbestos disposal site, located in the southwest portion of the landfill. Three holes are proposed along the axis of the cell, with one in the center and one at about 80 ft from each end of the cell. Each of the three boreholes will extend to at least 10 ft below visual evidence of waste disposal, or to the saturated zone, whichever is greater. This criterion for depth will probably result in boreholes that are approximately 40 to 50 ft in depth. Samples will be taken continuously to a depth of at least 20 ft and every subsequent 5 ft, or at changes in lithology. Selected holes will be completed as piezometers by installing a slotted pipe or well screen at or below the water level. The locations of these boreholes were chosen so that samples from different regions of the trench would be obtained. There is a strong possibility that drums were buried in this trench. Therefore, geophysical data must be used in siting final hole locations to avoid penetrating any drums that may be present.

Because of the uncertain knowledge of waste disposal, the initial analytical program will address all compounds on the target compound list (Table 4-8). In addition, samples will be examined for the presence of asbestos. Geologic logs will be prepared in the field and physical properties of selected soil samples will be determined in accordance with procedures listed in Table 4-9.

The second location in the landfill to be sampled is an area marked with two signs indicating "Burial Site" (Fig. 4-12). Two vadose-zone holes are proposed along the apparent axis of this area, each about 100 ft from the suspected ends of the burial site. These holes will be drilled to the saturated zone, or to at least 10 ft below the last evidence of disturbance or waste disposal, and water-level measurements will be taken upon completion. Similar precautions to those noted above must be taken to avoid drilling into drums. Analytical parameters will be the same as for the three boreholes in the first area, including analysis for asbestos.

The other locations where vadose-zone holes are proposed are at two areas of the landfill where visual evidence suggests that liquids and sludge may have been disposed of (Fig. 4-12). The first area is to the north and east of the burial site, along the eastern boundary of the landfill. There are two distinct pits, and one area between the two pits that may represent a backfilled pit. Three vadose-zone holes are proposed for this area, with one hole in each of the pits and one in the area between. In the westernmost pit, the hole will be located at the low point in the pit, because liquid waste disposed of in the pit is most likely to be concentrated at this point. In the easternmost pit, there is an area that contains a mound of broken glass, with rubber laboratory stoppers scattered around and in the mound. Based on discussions with personnel who have worked at the Hanford Site for many years, this glass is probably related to disposal of unwanted and potentially explosive compounds (e.g., picric acid, ethers, etc.). The proposed hole within this pit is at the location of the glass mound. A third hole will be drilled in the center of the area, where a backfilled pit is suspected.

The other area where liquid disposal is suspected is also along the eastern boundary of the landfill, about 1,000 ft south of the liquid disposal pits discussed above. The sludge in this area is not located in a pit, but in a low area of the landfill. The proposed vadose-zone hole in this area is at the lowest point, where any contaminants should be most concentrated. This low area is essentially along the eastern boundary of the landfill.

Samples from each hole in both of the liquid disposal areas will be taken continuously from the surface to a depth of 20 ft, and at 5-ft depth intervals or at changes of lithology from 20 ft down to the saturated zone. Chemical analyses will be performed on the 0-, 2-, 5-, and 10-ft depths, and at subsequent 10-ft samples down to and including the saturated zone. These analyses will address the target compound list compounds.

Eight groundwater monitoring wells are proposed at six locations surrounding the Horn Rapids landfill to investigate the hydrologic properties of the unconfined aquifer and to detect groundwater contamination from waste disposal at the landfill (Fig. 4-12). The spatial arrangement of the proposed wells is intended to provide two upgradient and four downgradient wells under a range of easterly to northeasterly flow directions. Geologic samples will be taken at 5-ft depth intervals and at changes in lithology during the drilling operations, to support hydrogeologic characterization. These samples will be described and tests for specific hydrologic parameters will be performed per the data quality objectives. One of the upgradient locations and one downgradient location will be well clusters with two wells 25 to 50 ft apart completed in the upper and lower portions of the unconfined aquifer. The purpose of the cluster wells is to determine if contaminant levels are stratified in the aquifer, an observation that is particularly important for dense liquid contaminants such as carbon tetrachloride. All other monitoring wells will be completed in the upper portion of the aquifer.

After completion of aquifer tests, the monitoring wells will be sampled quarterly for 1 yr. At the end of the 1-yr period, data on contaminant concentrations will be evaluated and a determination will be made on the need for additional sampling. Depth to the water table will be measured on the same quarterly schedule as the groundwater sampling. The need for additional water table mapping will be evaluated after a 1-yr period.

4.4.1.7 Geochemical Analysis of Soil Samples. If the RI phase data identify contamination of concern to the extent that modeling is required, additional data may be obtained during RI to determine contaminant release behavior. These tests will be designed to evaluate contaminant mobility at each of the major waste sites located in the 1100-EM-1 operable unit.

Contaminant release-rate experiments may be performed on composite samples obtained from each of the waste sites. Soil samples containing hazardous substances will be composited for site-specific leaching studies. Wastes will be leached in a column experiment to assess the mobility of hazardous substances found at each site.

Leachates generated from the waste-leaching experiments or other suitable means may be passed through composite sediment columns representative of each stratigraphic or lithologic unit. These studies will be performed to evaluate the geochemical behavior of hazardous substances as they migrate through the vadose zone from the near-surface environment to the groundwater.

Groundwater from the "affected environment" beneath these waste sites may also be used in column studies with composite sediments from the upper portion of the unconfined aquifer. If no groundwater contamination exists beneath a site, these aquifer geochemical tests may be redesigned and/or eliminated depending on the extent of contamination. Together, these geochemical analyses provide base-case information for the no-action alternative and the water-flushing alternative.

4.4.1.8 Disposal of Sampling Media. Sampling media include all soils and groundwater brought to the surface while drilling, coring, excavating, pumping, or using other methods in an effort to collect samples or to conduct tests. All media not part of the sample will be controlled according to appropriate procedures (see Appendix C).

4.4.1.9 Additional Groundwater-Monitoring Wells. In addition to the groundwater-monitoring wells to be drilled at each waste site as part of the RI Phase 1B, five additional monitoring wells have recently been drilled in the 1100 Area to the west and north of the north Richland well field. These wells were drilled as part of the site-wide groundwater monitoring program and are not considered part of the RI/FS effort, although data from these wells will be used as appropriate. In addition, other wells in the vicinity have been identified as available for sampling. These wells are summarized on Table 4-10. Locations of existing and proposed groundwater-monitoring wells are shown in Figure 4-13.

4.4.2 Atmospheric Characterization Program

The atmospheric component of the data collection program is divided into two major tasks. The first task involves characterization and monitoring of air quality, including collection of air samples in the ambient atmosphere upwind from the waste disposal site and samples in the potentially contaminated atmosphere downwind of the site. A comparison of the samples can be used to determine whether or not contaminants are being emitted to the atmosphere from the waste site in quantities that may have a significant environmental impact. The second task involves characterization of the meteorology of the site. This includes the monitoring of winds, atmospheric stability, and other parameters. These data are needed to estimate the atmospheric transport and diffusion of an effluent from a waste disposal site and the resulting ground-level air concentrations.

4.4.2.1 Air-Quality Monitoring. The air quality monitoring program will be designed to monitor air contaminants that may be associated with waste sites in the 1100 Area. Because there is some uncertainty as to the types and quantities of the various wastes at some of the sites in the 1100 Area, a broad spectrum of monitoring will be conducted. Specifically, the monitoring program will examine both volatile and semivolatile organic compounds, pesticides, PCBs, metals, and total suspended particulates.

Table 4-10. Available Wells in the 1100 Area. (sheet 2 of 2)

Well number[a]	Alternate name	Casing elevation (ft)	Diameter (in.)	Total depth (ft)	Perforated or screened interval (ft)	Year drilled	Current use
6-S37-E14	Temp #5	408.28	4	63	47 - 63	1988	Monitoring well
6-S40-E14	Temp #2	402.85	4	62	34 - 59	1988	Monitoring well
6-S41-E13A	Temp #1	410.56	4	67	47 - 63	1988	Monitoring well
6-S41-E13B	Temp #3	410.10	4	95	77 - 87	1988	Monitoring well
6-S43-E12	Temp #4	405.60	4	62	42 - 58	1988	Monitoring well
6-S31-E13	STES #6	394.06	8	100	50 - 68	1979	Monitoring well
6-S32-E13A	STES #1	390.46	8	100	50 - 68	1979	Monitoring well
6-S32-E13B	STES #7	394.72	8	100	50 - 70	1979	Monitoring well
6-S45-E10	6-ATH C	600.00					Irrigation well
6-S30-E15A	49-17A	400.39	6	80		1971	Monitoring well
6-S30-E15B	49-17B	399.58	6	93		1971	Monitoring well
11-34-13	1100-2	391.00	8	103	45 - 90	1948	Useable
6-S27-E14	3000-7	399.77	8	165	60 - 158	1948	Monitoring well
3-5-2	303-13	390.71	8	424	192 - 412	1954	Useable
	ORV #1		6	386	286 - 386	1982	Drinking water

NOTE: Does not include wells installed by Advanced Nuclear Fuels Corporation or Lamb-Weston.

[a]Well number is the Hanford well number (6 = 699 prefix, 11 = 1199 prefix, 30 = 3099 prefix, 3 = 399 prefix).

Table 4-10. Available Wells in the 1100 Area. (sheet 1 of 2)

Well number[a]	Alternate name	Casing elevation (ft)	Diameter (in.)	Total depth (ft)	Perforated or screened interval (ft)	Year drilled	Current use
11-37-16	3000-N	363.40	20	56	24 - 40	1961	City pump well
11-38-16	3000-K		20	59	15 - 50	1952	City pump well
11-39-15	3000-J	393.00	20	71	44 - 69	1952	City pump well
11-39-16A	3000-E	368.82	17	62	22 - 58	1948	City pump well
11-39-16C	3000-D	385.77	20	75	41 - 71	1948	City pump well
11-39-16D	3000-C	371.17	20	64	32 - 62	1948	City pump well
11-39-16E	3000-L	398.00	20	83	56 - 81	1953	City pump well
11-40-15	3000-A	395.93	20	88	47 - 81	1948	City pump well
11-40-16B	3000-B	392.82	20	90	47 - 84	1948	City pump well
11-40-16C	3000-H	381.00	20	55	25 - 50		City pump well
11-41-13C	3000-D-1	404.87	20	95		1944	Monitoring Well
30-42-16	3000-D-5	407.63	12	134	55 - 125	1944	City pump well
6-S28-E0	Patrol	448.45	8	236	90 - 180	1981	Drinking water
6-S29-E12	50-15	387.97	6	79	37 - 59	1971	Monitoring well
6-S30-E14	S30-E15C	401.39	2	3,540		1970	Monitoring well
6-S31-1	USGS #12	460.11	8	228	93 - 103	1951	Monitoring well
6-S36-E12A	STES #5	398.64	8	102		1979	Irrigation well
6-S36-E12B	STES #4	399.04	8	100		1979	Monitoring well
6-S36-E13A	STES #2	399.63	8	100	52 - 75	1979	Monitoring well
6-S36-E13B	STES #3	399.61	8	100		1979	Monitoring well

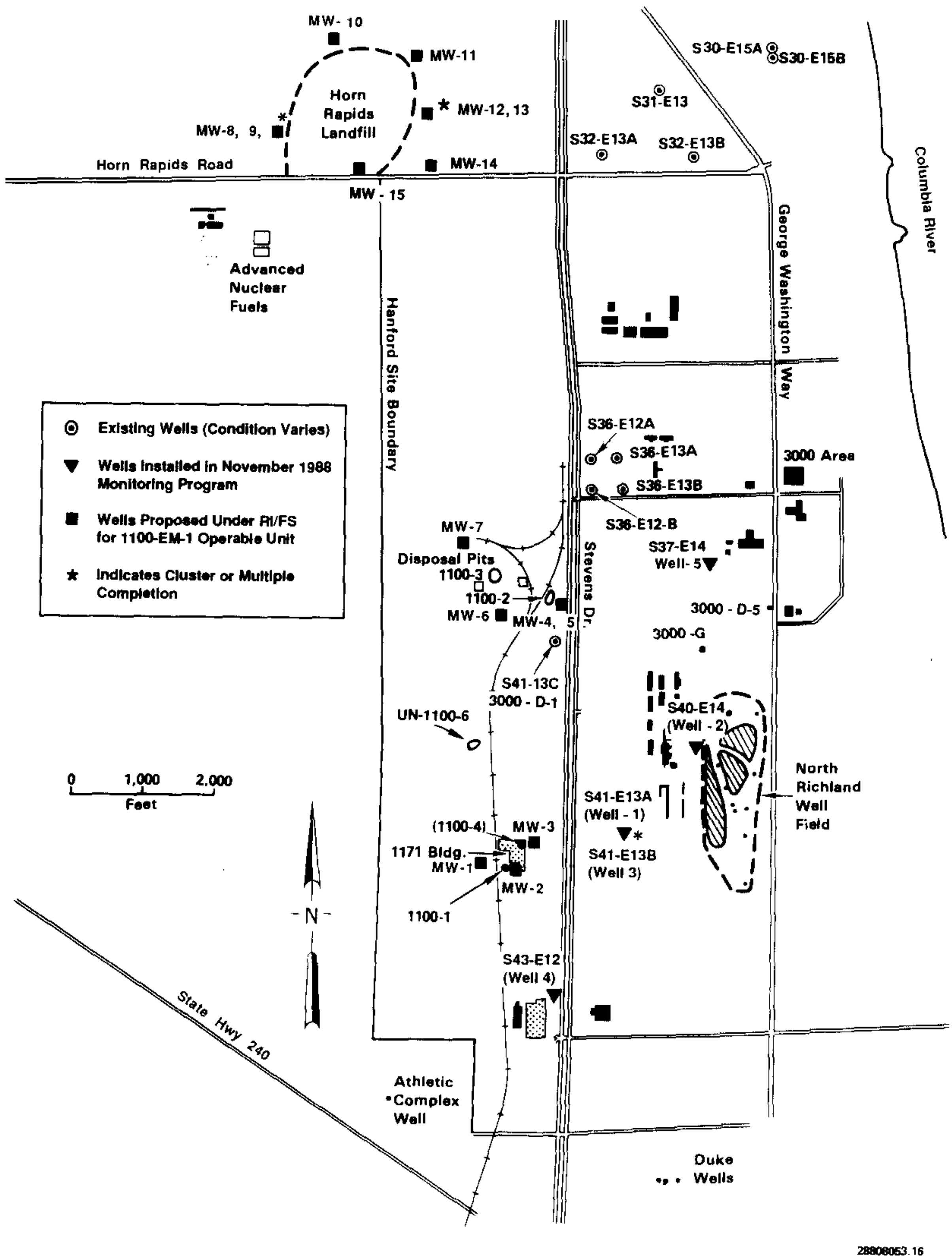

Figure 4-13. Locations of Existing and Proposed Groundwater Monitoring Wells.

The 1100 Area waste sites will be divided into three study areas: the Horn Rapids landfill, the central portion of the 1100 Area, and the area around the 1171 Building. Air monitoring in the central portion of the 1100 Area will focus on emissions from the "paint and solvent pit", the "antifreeze and degreaser pit", and the discolored-soil site. Monitoring near the 1171 Building sites will cover the battery acid pit.

4.4.2.1.1 Sampling Locations. Air quality monitoring at the three study areas will involve the collection of air samples upwind and downwind of the waste disposal sites. Upwind sampling will be conducted to determine ambient air quality independent of any influence from the waste sites. Downwind sampling will be conducted to determine the effects of atmospheric transport and diffusion on the air concentration of any pollutants emitted from the waste sites. Two downwind sampling locations will be selected to compensate for the normal meander in wind direction. Additional sampling for occupational safety purposes will be conducted at the waste site (see Section 6.0) to determine the concentrations of pollutants to which site workers may be subjected.

Specific locations for sampling will be determined based on the prevailing wind direction for the time of year that the sampling will be conducted, site activities, sources of potential contamination, and site security. Monitoring will be conducted during periods of light to moderate wind speeds, when wind directions are fairly constant. Because of the orientation of the prevailing winds in the 1100 Area, the upwind samplers are anticipated to be located about 310 ft southwest of the waste disposal sites, and the downwind samplers will be located a similar distance to the northeast of the disposal site.

Sampling will be conducted before, during, and after site analysis activities. Air quality sampling will be conducted before site investigation activities to determine if pollutants are being routinely emitted to the atmosphere from prior disturbance by sampling activities at the disposal site. Sampling will be conducted during site investigation activities to determine if subsurface sampling activities are providing a pathway for the emission of pollutants to the atmosphere. Finally, air quality sampling will be conducted after all subsurface and other surface sampling activities are completed to determine if air pollutant concentrations have returned to previous levels.

Sampling at the Horn Rapids landfill will be complicated by the presence of the Advanced Nuclear Fuels Corporation facility about 0.6 mi southwest of the disposal site. Sampling will be conducted at this site only when the nuclear fuels facility is not noticeably emitting pollutants to the atmosphere, or when these emissions are at a minimum. Additional sampling locations in the Horn Rapids landfill area may be required to characterize any influence from the nuclear facility will be sought to minimize any potential interference with our monitoring from activities at the nuclear fuels facility.

4.4.2.1.2 Sampling Equipment and Procedures. Three types of samples will be taken at each monitoring location. The first air sample will be for volatile organic compounds and will use one of the commercially available collection methods (e.g., carbon molecular seive). The second sample will be for semivolatile organic compounds, pesticides, and PCBs. This will also be collected using a commercially available collection method (e.g., polyurethane foam). The third samples will be for metals and total suspended particulates. This sample will be collected using high-volume filter sampling techniques.

Each air and particulate sample will be collected over a 4- to 12-h period, with the exact time depending on activities at the site and meteorological conditions. Unchanging wind directions (with allowances for the normal meander in wind direction) are required for sampling purposes. Sampling periods will be shortened if there is a significant change in wind direction. Procedures for operating, maintaining, and calibrating the sampling equipment will be according to the individual manufacturer's guidelines and applicable Hanford Site quality assurance procedures.

4.4.2.1.3 Analytical Methods and Data Processing. All samples will be collected, prepared for laboratory analysis, and analyzed using EPA-approved methods. The laboratory analysis for volatile organic compounds will be conducted using gas chromatography/mass spectrometry. The air sample to be analyzed for semivolatile organic compounds, pesticides, and PCBs will be split in half. The filter samples to be analyzed for metals and total suspended particulates will be processed using EPA guidelines.

4.4.2.2 Meteorological Monitoring Program

4.4.2.2.1 Sampling Locations. A comprehensive program of meteorological monitoring is in place at the Hanford Site. Meteorological data are collected at the Hanford Meteorological Station and at 24 additional automated monitoring stations located throughout the Hanford Site region (onsite and offsite). Two of the automated meteorological monitoring stations are located in close proximity to the 1100 Area. A 200-ft meteorological tower (the 300 Area station) is located less than 1 mi north-northeast of the Horn Rapids landfill and approximately 3 mi north of the 1171 Building in the 1100 Area. A second automated monitoring station is located at the top of the Richland Airport control tower, about 2 mi to the south-southwest of the 1171 Building. Continuous meteorological monitoring has been conducted at these two locations since early 1982.

Data from the Hanford Site meteorological monitoring network will be used to characterize the climatological conditions at the 1100 Area waste sites. Wind and air temperature data collected at the 300 Area station should be representative of meteorological conditions at the Horn Rapids landfill. There is uncertainty as to how representative the 300 Area and Richland Airport monitoring stations are of conditions in the central and southern portions of the 1100 Area. To determine the degree of representativeness, a short-term program of meteorological monitoring needs to be set up for the 1100 Area.

To study the meteorology of the central and southern portions of the 1100 Area, a 30-ft instrumented tower is proposed to be set up at a west-central location in the 1100 Area. This location will be selected so as to minimize the effects of buildings, trees, and other structures on local wind flow patterns. Data from the site will be compared with data from the 300 Area and Richland Airport monitoring sites. If one of these two meteorological monitoring stations is found to be representative of conditions at the disposal sites, monitoring at this location can be discontinued and data from the representative station will be used in future analysis work. If neither of the sites provides a satisfactory representation of the meteorology at the disposal site, the short-term meteorological monitoring at the site will be continued for as long as data are required.

Because of the number and the size of the buildings in the southern portion of the 1100 Area, these structures can have a significant impact on local winds and temperatures. For this reason, additional meteorological monitoring may be required near the 1171 Building to adequately characterize the impact of the building on the near-surface winds and air temperatures experienced at the nearby waste sites.

4.4.2.2.2 Sampling Equipment and Procedure. Short-term meteorological monitoring in the west-central portion of the 1100 Area will involve the deployment of a meteorological tower at least 30 ft high. Measurements of wind direction, speed, and air temperature will be made at approximately 30 ft and 6 ft above ground level. Data will be automatically recorded and transmitted to the Hanford Meteorological Station. The monitoring station will be calibrated using the same standards employed for the stations in the Hanford Site meteorology monitoring network. The period of operation of the station will depend on the representativeness of data collected at the 300 Area and Richland Airport monitoring stations. Monitoring may encompass the entire period of air quality monitoring and may be continued beyond the end of the project as part of routine Hanford Site meteorological monitoring.

The monitoring of meteorological parameters near the 1171 Building will be conducted during operations and air quality sampling at the site. The instrumentation used at this site will be comparable to the instrumentation to be employed at the west-central 1100 Area monitoring site.

4.4.3 Biota

Biotic surveying or sampling is not planned for the battery acid pit (1100-1), the antifreeze tank site (1100-4), or the radiation contamination incident location (1100-5). These sites are generally devoid of vegetation and do not provide a habitat conducive to small animals.

The disposal pits (1100-2 and 1100-3) and the discolored-soil site are inhabited by vegetation such as cheatgrass, tumbleweed, and rabbitbrush, as is typical for disturbed areas at the Hanford Site. There is also evidence of burrowing animals (pocket mice and badgers) at these sites.

The Horn Rapids landfill exists in a similar ecologic setting. However, because of its size, it can be expected to harbor a greater diversity of animal and plant species.

A visual reconnaissance effort will be conducted at these sites by qualified personnel to locate and evaluate any evidence of uptake of toxic substances by plants or animal. Any evidence of weakened, necrotic, or chloritic plants will be documented by species. Observations would also be made of evidence of small mammals and bird species and animal-burrowing activities. Where possible, at least two soil samples from pocket mouse or badger mounds will be collected at each site and analyzed as discussed in Section 4.4.1. A threatened and endangered species survey will also be conducted as part of the biotic reconnaissance effort.

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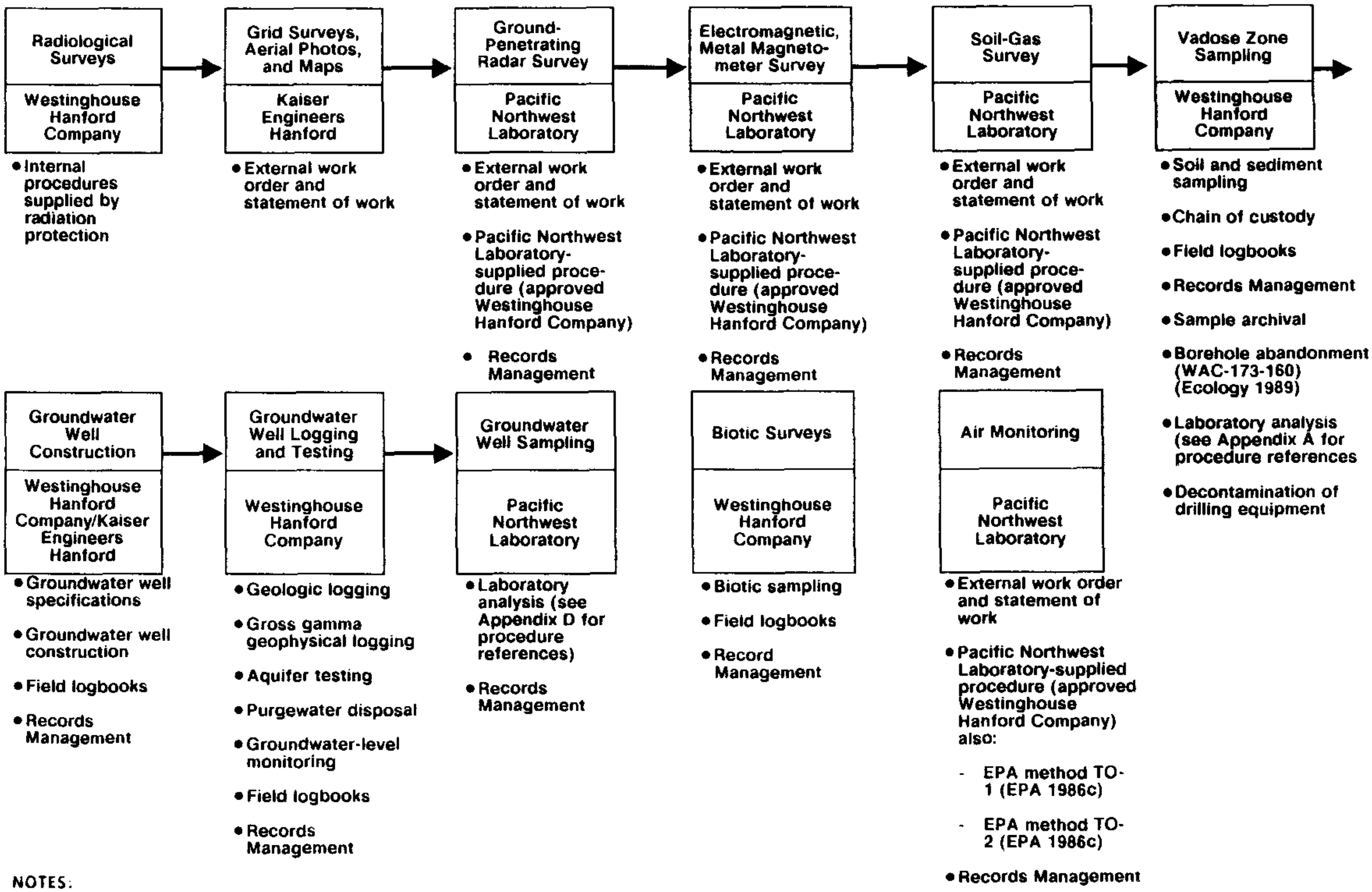
5.0 QUALITY ASSURANCE PLAN

5.1 INTRODUCTION

The basic objective of the QA plan is to ensure that data, findings, and results are sufficiently accurate and reliable to support decisions associated with site evaluation, risk assessment, and evaluation and selection of remedial alternatives. In addition, activities will be based on approved plans and procedures and adherence to plans and procedures must be enforced and documented. Where necessary, changes to approved procedures and plans will be made in a controlled manner, and adequate documentation will be maintained. Traceability will be established and maintained between results and findings used in making decisions and the original measurements and/or samples.

To achieve the basic QA objective stated above, internal QA documents (Figure 5-1) will be used that address the applicability of nuclear QA requirements (ANSI/ASME NQA-1 1986) to RI/FS work. These documents, in conjunction with the procedures listed in Figure 5-1 and Appendix C, provide the basis for a QA program that satisfies DOE-RL Order 5700.1A (1983) and EPA and internal Westinghouse Hanford QA requirements. Another document will discuss the 18 quality elements of ANSI/ASME (1986) and relate them to EPA QA guidance document requirements. The document will address such areas as the following:

- Management policies
- Organization charts and charters
- Management requirements and procedures
- Document clearance and information release
- Records management
- Quality assurance
- Operational health physics
- Standard engineering practices
- Radioactive solid waste packaging, storage, and disposal requirements
- Publication style
- Procurement.



NOTES:
- See Appendix C for details regarding procedures in process (procedures will be cleared for public release).
- EPA = U.S. Environmental Protection Agency.
- WAC = Washington Administrative Code.

Figure 5-1. Matrix of Specific Procedures.

5.2 PROJECT QUALITY ASSURANCE ORGANIZATION AND RESPONSIBILITY

Overall project organization and responsibility are discussed in Section 3.0. An organization chart is provided in Figure 3-1. Work associated with the RI/FS will be carried out under the direction of Westinghouse Hanford acting for the DOE. In this capacity, Westinghouse Hanford is responsible for planning, implementing, and maintaining a QA program in accordance with DOE-RL Order 5700.1A (DOE-RL 1983). The purpose of this section is to define the responsibilities of the technical lead, the RI coordinator, the field team leaders, and the quality coordinator with regard to quality assurance.

Figures 3-3 through 3-8 illustrate the organizational structures used to carry out specific RI activities. The technical lead is the designated individual from Westinghouse Hanford responsible for the overall direction of the RI/FS work.

The RI coordinator is the designated individual from the Westinghouse Hanford Environmental Engineering Group who is responsible for coordinating RI activities and ensuring that all laboratory analysis activities are carried out in accordance with approved plans and procedures. The RI coordinator will also supervise data assessment and evaluation carried out by the appropriate RI technical resources.

The field team leaders are designated individuals from Westinghouse Hanford, PNL, or subcontractors who are responsible for a particular sampling or field investigation activity. The field team leader is responsible for ensuring that field investigation and sampling activities are carried out in accordance with approved plans and procedures. The field team leader will also maintain calibration and maintenance records for field equipment and will supervise collection, preparation, handling, storage, and custody of samples, including field quality control (QC) samples.

The quality coordinator will verify compliance with plans and procedures by conducting audits, surveillances, and inspections, and will verify that data assessment and evaluation have been completed and documented.

5.3 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT

The suitability of data to support important decisions associated with the RI/FS process can be stated in terms of the validity and reliability of the measurement and the degree of uncertainty associated with numeric values. Validity and reliability are established primarily through implementation of a QA program to ensure that all measurements are taken in accordance with approved plans and procedures and that adequate documentation is maintained to provide traceability and accountability. Uncertainty of measurement data is stated in terms of precision, accuracy, representativeness, completeness, and comparability parameters.

Specific objectives are discussed in Section 4.3.4 and stated in Table 4-3 as DQOs. Because relatively little site-specific data are available, the DQOs are stated in qualitative terms. More specifically, quantitative DQOs will be provided for subsequent phases of the RI work as specific contaminants are identified, site characteristics become better known, and remedial objectives become better defined.

5.3.1 Precision and Accuracy

Precision measures the reproducibility of measurements under a given set of conditions, while accuracy refers to the difference between the measurement and the true value. Specifically, precision is a quantitative measure of the variability of a group of measurements compared to their average (mean) value. Precision is generally stated in terms of the standard deviation. Accuracy is a quantitative measure of the closeness of an individual measurement or the mean of a set of measurements to the true value. Accuracy is generally stated in terms of percent recovery, based on analysis of measurements of a reference sample of known value. It is possible to have a set of measurements with high precision but low accuracy.

The overall precision and accuracy of a set of measurements is a function of both sampling and analytical factors. Sampling factors are typically unique for each site. They include the inherent variability of the measurement itself, the errors associated with the sampling process, and other factors such as field contamination and sample preservation, handling, and transportation. The degree of error associated with sampling factors is evaluated by analysis of field QC samples as discussed in Section 5.3.5.

Analytical factors are related to the performance of the laboratory. The degree of error associated with analytical factors can be estimated from evaluation of historical laboratory data, including analysis of laboratory quality control samples carried out in accordance with the laboratory QA plan.

5.3.2 Representativeness

Representativeness expresses the degree to which parameters, based on evaluation of the sample data, correctly represent the characteristics of the population from which the samples were taken. Representativeness is a qualitative parameter that is obtained by proper planning of the sampling program, particularly with regard to selection of sampling sites and sample collection methods.

5.3.3 Completeness

Completeness is defined as the proportion of measurements that are judged to be valid in relation to the number of measurements that are necessary (or should have been made) to satisfy a DQO.

The final determination as to whether or not sufficient valid data have been collected can only be made after the data are evaluated with regard to their intended use, taking into account an improved understanding of site conditions that results from the data collection program.

For example, in the initial phases of the RI/FS process where the goal is identification of any contaminants on the site, relatively little data may be sufficient to support the required decision as to whether or not remediation of a particular contaminant is required. However, considerably more data may be required to select an appropriate remedial action.

5.3.4 Comparability

Comparability is a qualitative parameter that expresses the degree to which one set of measurement data can be compared to a similar set. The goal of comparability is achieved through the conformance to approved procedures for both sample collection and laboratory analysis. Analytical results must be reported in appropriate units to facilitate comparison. The degree of comparability between data sets also depends to some extent on the accuracy, precision, and representativeness of the measurements.

5.3.5 Field Quality Control Sampling

This section presents a general discussion of field QC samples. Specific recommendations regarding each sampling method and environmental medium are discussed in Section 5.3.6.

Five general categories of field QC samples can be collected to support data evaluation. The applicability and frequency of these samples depend on the medium. Analysis of these samples will support evaluation of accuracy, precision, and representativeness.

- Blanks are samples containing no contamination, used to check for the introduction of contamination during sample collection and/or handling. These include: equipment or field blanks, which are collected by passing contaminant-free water (or other media) through the field sampling equipment; and trip blanks, which are prepared in the laboratory to accompany the sample containers to and from the sites. Typically, at least one field blank is prepared for every 20 samples, and one trip blank is prepared for each day or episode of sampling.

- Duplicates or collocated samples are multiple samples of the same medium taken at the same location (or very close). Replicates are two or more aliquots of the same sample. Field replicates may be produced by splitting a sample in the field. Laboratory replicates are produced by splitting the sample after it has arrived at the laboratory. Field replicates or collocated samples are typically collected at least once for every 20 samples. The frequency of laboratory replicates is specified in the laboratory QA plan.

- Interlaboratory splits are duplicate or replicate samples sent to different laboratories to independently assess the accuracy and precision of the laboratory data.

- Blind standards contain a known contaminant level. They are submitted to the laboratory as field samples to independently verify the degree of analytical bias.

- Matrix spikes are samples to which a known amount of the analyte has been added. When prepared in the field immediately after sample collection, field spikes provide a good assessment of matrix effects, as well as sampling, handling, and preservation error. However, the use of field matrix spikes is generally not recommended because of the high level of technical expertise required for their successful use and their sensitivity to environmental variables. Errors in preparing the spike may result in serious problems in interpretation of the sampling data. Therefore, field matrix spikes will not be prepared unless specifically noted. Matrix spikes may be prepared in an independent laboratory to assess laboratory performance and sensitivity to matrix effects.

The effects of analytical and sampling factors on precision can be determined by collecting and analyzing collocated or field replicate samples and then creating and analyzing laboratory replicates from field samples. The analytical results from the collocated or field replicate samples provide information on overall precision. Analytical precision is determined from the results of the laboratory replicates and from internal laboratory quality control samples. The sampling precision is then the difference between the overall precision and the analytical precision.

Sampling accuracy, which includes preservation and handling, can be evaluated by the use of field and trip blank samples. Analytical accuracy can be evaluated by the use of known and unknown QC samples (standards) and matrix spikes.

Field blanks will be prepared and analyzed to assess the potential for contamination from sampling equipment, which may affect the representativeness of the data. Analysis of collocated or field replicate samples also provides information on the representativeness of the data.

Field QA samples will be documented in the field logbooks and submitted to the laboratory in the same manner as other samples, with no specific identification to differentiate them from other samples. The results of the field QA samples are used to assess the overall quality of the data obtained from the sampling and analysis program.

5.3.6 Media-Specific Field Quality Control Sampling

The following discussion identifies specific types and frequency of collection for field QC samples or measurements.

5.3.6.1 Geophysical Surveys. The field QC effort will consist of duplicate measurements for every twentieth point for point survey methods (such as EM, soil resistivity, or metal detection). For line survey methods (such as ground-probing radar), duplicate or repeat surveys will be made at least once at each site. For geophysical logs, a repeat section (duplicate) of at least 10 ft will be run at least once in each hole for each logging tool.

5.3.6.2 Soil-Gas Survey. Because the soil-gas survey is basically a laboratory procedure run in the field, the field QC samples serve a dual function of both field and laboratory performance assessment. Blanks will be run for every tenth sample, and a field replicate and standard will be run for every twentieth sample.

5.3.6.3 Air-Quality Sampling. A blank will be collected at each sampling site for volatiles and semivolatiles. No other field QC samples are deemed appropriate for air sampling in this phase.

5.3.6.4 Biota. If biotic sampling is implemented, one collocated sample will be collected for each shrub species. No other field QC samples are deemed appropriate in this phase.

5.3.6.5 Sediment and Soils. No field QC samples will be collected for physical properties in this phase of the RI. However, samples not tested will be archived for future evaluation where feasible. For chemical analyses, at least one field replicate will be collected for every 20 samples, with a minimum of one field replicate at each site. At least one interlaboratory split will be collected for the core 1100 Area and the Horn Rapids landfill.

5.3.6.6 Groundwater. At least one trip blank will be prepared for each day of sampling. One field blank will be collected for each 20 samples, with at least one field blank for each episode of sampling. Field replicates and interlaboratory splits will be obtained from at least one well in the 1100 Area and one well in the Horn Rapids landfill for each episode of sampling. Assuming that all wells will be sampled at approximately the same time, one set of appropriate blind standards will be prepared for every round of sampling. Groundwater samples will generally not be archived, due to holding time restrictions.

5.4 PROCEDURES

Procedures applicable to each step of the initial RI work (Phases 1A and 1B) are indicated in Figure 5-1. Further discussion follows in the sections below.

5.4.1 Field Sampling Procedures

Field sampling and data collection procedures are listed in Appendix C. These procedures are incorporated in a manual of environmental investigation and site characterization procedures. These procedures address the specific methodology for data collection during site characterization activities. Procedures required for field investigation activities that are not identified in Appendix C will be either written and approved as required or provided by the subcontractor or PNL to the technical lead for review and approval prior to initiation of the work.

5.4.2 Sample Custody

Chain-of-custody procedures will be observed for all field samples. Other field measurements and sampling information will be noted on field data sheets and will be logged in controlled field logbooks. A chain-of-custody procedure is included in the environmental investigation and site characterization manual.

5.4.3 Analytical Methods and Procedures

Laboratory analysis of all soil and water samples will be conducted in accordance with EPA-approved analytical procedures and QA/QC protocols as defined in the statements of work for organic and inorganic analytes for the CLP (EPA 1988d, 1989).

5.5 CALIBRATION AND PREVENTIVE MAINTENANCE

The term "measurement and test equipment" refers to devices and/or systems used to acquire measurement data or to determine compliance with design specifications or other technical requirements. Measurement and test equipment and reference standards shall be subject to calibration and preventive maintenance in accordance with appropriate Westinghouse Hanford manuals or vendor-supplied procedures. Documented procedures shall be used for calibration and preventive maintenance activities. Where appropriate, these may include published standard practices or written instructions from the vendor that accompany the equipment. For vendor supplied services, the statement of work will require Westinghouse Hanford review and approval of such standard practices and instructions.

5.6 FIELD DEVIATIONS

Field conditions cannot always be sufficiently anticipated during planning efforts. Numerous circumstances encountered in the field can make strict adherence to plans and procedures impossible. These circumstances can include (but are not limited to) equipment limitations, weather conditions, unanticipated soil conditions, previously unidentified barriers, and overly optimistic evaluations of capabilities. Modifications to the planned activity may be necessary when limiting field conditions are encountered. Basically, the following steps will be taken.

- Modifications to the planned activity will be determined that allow completion of the activity objective.

- The conditions of noncompliance, the proposed modifications made to the planned activity, and justification for the modifications will be reported on an instruction change authorization form by the field team leader.
- The field team leader will determine and obtain the required level of management approval based on the impact of the modifications.

Under certain conditions (e.g., a field crew is working in a controlled zone), the field team leader, with concurrence from the site health and safety officer and the site quality coordinator, may immediately implement an instruction change authorization. The required approvals must subsequently be obtained within two working days of the deviation by the team leader. Rejection of the deviation by the approval authorities will result in repeating the activity at a later date.

5.7 DATA REDUCTION AND REPORTING

This section discusses methods by which the data collected during the RI/FS will be presented. Data management is discussed in Section 8.0. Care will be taken to ensure that traceability is maintained and assumptions are documented so that the more complex presentations do not conceal or distort conditions represented by the raw data. Raw data (the final reported result of a single analysis) will be presented in appendices or in separate data reports to serve as a record of the data collected and to facilitate independent analysis of the results. Raw data will be cited in the report text or reported in figures and tables where appropriate. In addition, data summaries will be prepared to reduce the volume of raw data and to represent basic characteristics with summary statistics. Every attempt will be made to use graphical data presentation where feasible to aid in interpretation by responsible technical staff and other users and reviewers. Where appropriate, statistical hypothesis tests and statements of statistical confidence will also be included.

5.7.1 Raw Data

The most basic form of data presentation is tabulation of raw data. Raw data will be stored in the Hanford Environmental Information System (HEIS) as discussed in Section 8.0. Along with the actual data values themselves, all qualifying information needed to identify the conditions under which the data were collected will be included. Some of these qualifiers are specific to each datum, while others are generic and will be included as headers or footnotes to a data list. They include the following:

- Specific (to be included with each value)
  - Location — Fully identify location of sample
  - Time — Fully identify date and time of sampling, and duration of sampling event as appropriate

- Data quality flags — Several types of data quality flags will be developed to identify potentially false data and alert data users to conditions that affect the evaluation of the data

- Generic (typically included in headers or footnotes)

  - Why sampled — Identify the purpose of the data
  - How sampled — Identify the sampling methods used
  - Who sampled — Identify who sampled the data (both individual(s) and firms)
  - How analyzed — Identify analytical methods used
  - Who analyzed — Identify who analyzed the data (not personnel, but firms)
  - Detection limit — The detection limit of the analytical procedure should be included with each data point
  - Level of concern — Where appropriate, levels of concern should be identified, along with identification of the ARAR or other documentation that addresses the level of concern.

In presentation of the data, care will be taken in the number of significant digits reported and data will be reported in comparable units.

5.7.2 Data Summaries

Data summaries will be used to present pertinent characteristics such as counts of samples taken, number of samples above the detection limit (where appropriate), minimum values, maximum values, median and mean values, standard deviations, and coefficients of variation. At this level, potentially complex statistical issues of probability sampling, less-than-detection-limit data, non-normality, variance component analysis, and spatial or temporal correlation will not be addressed. Summaries will be used for different subgroupings of the data as appropriate.

5.7.3 Graphical Presentations

Whenever appropriate, the data will be graphically presented to aid in interpretation. Methods of presentation of spatially variant data will include the two-dimensional graphics with raw data values located on a site map or discrete values indicated by three-dimensional views. Where appropriate, contour plots may be prepared. Generally, contour plots will include locations of raw data values to facilitate evaluation of the gridding and/or interpretation process used in contouring the data.

5.7.4 Statistical Evaluations

Types of statistical analyses that may be appropriate include the following:

- Hypothesis tests between waste site samples and background samples
- Probability statements concerning location(s) and size of "hot spot"
- Statement of statistical confidence level for average contamination levels or total contaminant inventory.

The QA data presentations that may be appropriate are the following.

- Field replicate or collocated data and interlaboratory split data will be reported in raw form, as well as relative percent differences, standard deviations, and coefficients of variation. Averages of these three measures will be calculated for similar types of data.
- The total number of field blanks, the number that were above detection limits, and data values above detection limit will be reported.
- Blind standard data will be reported along with the true value, bias, and relative bias for each measurement as well as averages of bias and relative bias for similar types of data.

In addition to sampling and analytical variability, indications of environmental variability and uncertainty are needed to assess the value of the data collected and to evaluate whether or not sufficient data have been collected to characterize the media as required by the DQOs.

For spatial variability, the appropriate measures of variability depend on the amounts and types of data that are collected. For measurements that will typically have relatively few data points, such as air, biota, and groundwater, the data presentation will consist of (as a minimum) the mean, variance, standard deviation, and coefficient of variation for similar types of data. For measurements that have relatively many data points distributed over space, (e.g., soil-gas measurements) geostatistical techniques will be used to provide variance contours.

5.7.5 Identification and Treatment of "Outliers"

As noted in a previous section, data quality flags will be used in reports of the raw data to identify which may be false or inappropriate for evaluation (outliers). Data quality flags will be based on criteria that include the following:

- Values less than detection limits for chemical analyses

- Values less than counting error for radioactive analyses
- Missing values.

Corrective actions may be required when outliers are identified. The procedure for determining corrective actions is described in Section 5.8.4. Corrective actions may include the discarding of the false data and the elimination or correction of the sources.

5.8 AUDITS, SURVEILLANCE, AND DOCUMENTATION

Audits, surveillances, and inspections will be carried out and documented in accordance with applicable sections of appropriate Westinghouse Hanford quality assurance manuals.

5.8.1 Definitions

5.8.1.1 Audit. An audit is a planned and documented activity performed to determine, by investigation, examination, or evaluation of objective evidence, the adequacy of and compliance with established procedures, instructions, drawings, and other applicable documents and the effectiveness of their implementation. It may also involve the review of documents or data management systems, laboratory or field equipment, and laboratory or field procedures. Internal audits are audits performed on Westinghouse Hanford activities by Westinghouse Hanford QA auditors or their designees (subcontractors). External audits are audits performed on suppliers and contractors (including analytical laboratories) by Westinghouse Hanford QA auditors or their designees (subcontractors).

5.8.1.2 Surveillance. Surveillance is the act of monitoring or observing to verify whether or not an item or activity conforms to specified requirements.

5.8.1.3 Inspection. Inspection is the act of monitoring or observing to verify whether or not a material, equipment, or hardware conforms to specified requirements.

5.8.2 Frequency and Planning

5.8.2.1 Audits. Internal and external audits of work shall be scheduled at a frequency commensurate with the status and importance of activities. Audit frequency shall include consideration of information from various sources, such as previous audits and program/project schedules.

Audit schedules shall be reviewed and revised as necessary to verify the implementation of the QA program.

Regularly scheduled audits shall be supplemented by additional audits of specific subjects when necessary to enhance the effectiveness of the QA program.

Audits shall be scheduled as early in the life of new activities as practical and shall be continued at intervals consistent with the schedule for accomplishing the activity.

5.8.2.2 Surveillance. Surveillance of activities shall be scheduled at a frequency commensurate with the status and importance of activities. Surveillance frequency shall include consideration of information from various sources, such as previous surveillances and program/project schedules.

A surveillance plan for each activity shall be established at the earliest time consistent with the schedule for accomplishing the activities by the cognizant engineer and the cognizant Quality Engineer and approved by their managers.

5.8.3 Documentation and Reporting

5.8.3.1 Audit. An audit report prepared by auditing personnel shall include the following:

- Description of the audit scope
- Identification of the auditors
- Identification of persons contacted during audit activities
- A summary of audit results, including a statement on the effectiveness of the QA program elements audited
- A description of each audit finding and observation in sufficient detail as to enable corrective action to be taken by the audited organization
- The signature of the audit team leader.

The audit report shall be addressed to the management of the audited organization or to the management having responsibility for response.

5.8.3.2 Surveillance/Inspection. Results of surveillance shall be recorded on an Inspection/Surveillance Report that shall contain the following:

- A discrete tracking number
- The name of the surveillant
- Date of surveillance
- Result of surveillance

- Identification of problem areas
- Identification of any unsatisfactory conditions and the person notified
- Activities surveyed
- Personnel contacted during the survey.

The inspection/surveillance report shall be addressed to management of the activity that has been surveilled or to the management having responsibility for response.

5.8.4 Corrective Action

Corrective actions may be required in response to the findings of surveillance reports, nonconformance reports, or audit activity. Conditions adverse to quality shall be documented and dispositioned in accordance with Westinghouse Hanford policies and procedures. Basically, this procedure entails the identification, investigation, and correction of the conditions adversely affecting quality, and establishes the documentation required to record the process.

Copies of all surveillance, nonconformance, audit, and corrective action documentation shall be routed to the project records upon completion or closure.

6.0 HEALTH AND SAFETY PLAN

6.1 INTRODUCTION

The health and safety plan (HASP) generically addresses potential health and safety issues associated with the RI of several CERCLA sites in the 1100 Area. This chapter will be supplemented by pre-job safety plans (PJSP) that are specific to all health and safety issues for each site investigation activity. Therefore, the information contained herein should be considered as reference material to be used primarily as upper-tier documentation for more job-specific safety plans. The onsite controlling document for risk identification and mitigation will be a Westinghouse Hanford-approved PJSP.

The purpose of the PJSP is to assign responsibilities, specify mandatory operating procedures, establish general personnel protection standards, and provide contingencies for emergency situations that may arise during RI.

This chapter is divided into the following areas for ease of referral. Section 6.2 projects and evaluates the probable hazards associated with the waste sites. Section 6.3 lays out a protection strategy to ameliorate the hazards identified in the previous section. Section 6.4 identifies the recommended and mandatory personnel training requirements necessary to perform remedial investigations. Section 6.5 emphasizes the importance of pre-job safety meetings and monitoring by the site safety officer (SSO). Section 6.6 outlines a preliminary personnel medical surveillance program to track all workers involved in field investigations (the surveillance program will become extremely important if workers are to be used for up to several hundred remedial investigations at the Hanford Site that may eventually be required). Section 6.7 identifies emergency information necessary in case of spills, accidents, environmental releases, and/or injuries. Finally, Section 6.8 identifies the procedures required for individual jobs, the most important of which is the PJSP.

This plan has been prepared in accordance with the requirements established by the EPA (1985c, 1985d) and the National Institute for Occupational Safety and Health (NIOSH) (1985) and meets the requirements outlined by DOE, the Occupational Safety and Health Administration (OSHA), and the State of Washington. However, note that this plan cannot stand by itself unless combined with Section 2.0, "Site Description."

6.1.1 Safety-Related Site Characteristics

From a health and safety perspective, the investigations of the 1100 Area sites will be somewhat unique (from other investigations on the Hanford Site), as depicted in Table 6-1. Therefore, additional precautions may be required as discussed in Sections 6.2 and 6.3.

Table 6-1. Unique Characteristics of 1100 Area Sites.

Waste site	Unique characteristics
1100-1 Battery acid pit	Adjacent to occupied buildings Extensive local traffic (pedestrian, rail, motor vehicle) Relatively close to public drinking water supplies Small dimensions Upwind of commuter traffic Easily visible/not secured
1100-2 "Paint and solvent pit"	Close to rail traffic Relatively close to public drinking water supplies Exact quantities and locations of waste unknown Upwind of commuter traffic Easily visible, not secured
1100-3 "Antifreeze and degreaser pit"	Close to rail traffic Relatively close to public drinking water supplies Exact quantities and locations of waste unknown Upwind of commuter traffic Easily visible, not secured
1100-4 Antifreeze tank site	Extensive local traffic Relatively close to public drinking water supplies Unknown if tank actually leaked Upwind of commuter traffic Remedial investigation will interrupt maintenance activities Easily visible, not secured
1100-5 Radiation contamination site	Extensive local traffic Exact location unknown Relatively close to public drinking water supplies Upwind of commuter traffic Remedial investigation will interrupt maintenance activities
Horn Rapids landfill	Extensive commuter traffic on two sides Relatively close to public and private drinking water supplies Bottom of cells in or just above groundwater Municipal waste present Extensively large and diverse site Subsidence problems may exist Easily visible, not secured Wide variety of chemicals suspected Could require sampling in vicinity properties Potential pressurized drums, etc. Potential fire or explosion hazards Potential laboratory/hospital waste

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6.1.2 Safety Groupings

Because the majority of these 1100 Area sites are also unique from one another from a health and safety perspective, they are broken down into the following groupings in Section 6.2:

Site groups	Name or number
Horn Rapids	Horn Rapids landfill
Battery acid pit	1100-1
Radiation contamination site	1100-5
All others	1100-2, 1100-3, 1100-4, and "Discolored-soil site".

6.2 HAZARD EVALUATION

Table 6-2 identifies potential safety and health hazards by type of 1100 Area site, as discussed in Section 6.1. In general, the Horn Rapids landfill is believed to present both the largest variety and the most significant of these potential hazards.

Due to the direct disposal or decomposition of solid wastes, methane or hydrogen could be present at some 1100 Area locations. Intermittent combustible gas measurements will be made, with warning levels established at 10% of the lower explosive limit (LEL). All operations will be halted if the LEL exceeds 20%. Precautions will be taken via continuous monitoring if the LEL is between 10% and 20%.

6.2.1 Subsidence

Subsidence is a common problem at the Hanford Site solid waste burial grounds. Precautions shall be taken to prevent injury to personnel or loss of equipment for all 1100 Area sites in which large volumes of solid waste were disposed of (i.e., Horn Rapids landfill). These precautions include bridge-supporting of drill rigs, personnel control, and remote sensing or probing to determine subsidence potential or alternative drilling techniques.

6.2.2 Corrosives

A common hazard to several of the 1100 Area sites, in particular the battery acid pit (1100-1), is the presence of acids. Although soil has some natural buffering capacity, acidified soil is expected to continue to be a hazard to personnel if not handled appropriately and if deep migration has not occurred.

Table 6-2. General Hazards of 1100 Area Sites.

Potential hazard	Waste site			
	Horn Rapids	Battery acid	Radiation contamination site	All others
Methane/ flammable gas	X	X	X	
Subsidence	X			X
Corrosives	X	X		X
Heavy metals	X	X	X	X
Organics	X			X
Radiation			X	
Electrical		X	X	X
Heat stress	X	X	X	X
Lighting	X			X
Noise	X	X	X	X
Sanitation	X			X
People proximity	X	X	X	X
Access/egress		X	X	X
Asbestos	X			
Wind-spread contamination	X	X	X	X

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Sulfuric acid can be toxic if inhaled or swallowed; it has a threshold limit value of 1 mg/m^3 and can be detected through the use of a colormetric tube. The most likely exposure route is through direct contact with the skin. As a precaution, whole body-level "C" protection, as discussed in Section 6.3, should be considered.

6.2.3 Heavy Metals

Heavy metals, in the form of particulates, are suspected at most sites. Precautions will be taken to prevent the excavation and resuspension of these materials through the use of water mists, excavation permits, and respiratory protection.

6.2.4 Organics

In almost all cases, organics should be assumed to have been disposed of at all of the 1100 Area waste sites, at least in the form of degreasers, antifreeze, and paint solvents. The most significant public health hazard associated with these compounds is inhalation of the vapor. The threshold limit value of common organics are shown in Table 6-3. Most of these compounds are flammable and are toxic if ingested or inhaled.

Table 6-3. Threshold Limit Values for 1100 Area Site Organics.

Compound	CAS[b]	Threshold limit value[a]	
		(mg/m^3)	(p/m)[c]
Methyl ethyl ketone	78-93-3	590	200
Ethylene glycol	107-21-1	125(C)[c]	50(C)[d] (vapor)[e]
Trichloroethylene[f]	79-01-6	270	50
1,1,1 Trichloroethane	71-55-6	1,900	350
Acetone	67-64-1	1,780	750
Toluene	108-88-3	375	100
Methylene chloride[f,g]	79-09-2	175	50
Carbon tetrachloride[f,g]	56-23-5	30	5 (skin)[h]
Tetrachloroethylene[f]	127-18-4	335	50
1,1,2,2 - Tetrachloroethane[f]	79-34-5	7	1 (skin)[h]

[a]The threshold limit values are time-weighted average concentrations for a normal 8-h workday and a 40-h workweek to which nearly all workers may be repeatedly exposed, day after day without adverse effect.
[b]Chemical Abstract System number.
[c]p/m = parts per million.
[d]The (C) indicates ceiling value; concentration should not be exceeded during any part of the working exposure.
[e]The (vapor) notation indicates that substance may act as a simple asphyxiant
[f]Suspected or known carcinogen per other sources (NIOSH).
[g]Suspected human carcinogen (ACGIH).
[h]The (skin) notation indicates that cutaneous contamination may be important.

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Direct-reading instruments will be used to detect the possible presence of organics (i.e., photo ionization instruments and organic vapor analyzers). If levels 3 p/m above background in the breathing zone are detected with general survey instruments, personnel will be prepared to cease operations and to fall back to the command post, and monitoring will increase in frequency. Every effort will be made to identify the potentially hazardous material as quickly as possible. If levels 5 p/m over background in the breathing zone are detected, personnel will cease operations and fall back to the command post for further instructions. Levels above background will be investigated to identify the potentially hazardous substance. It is further anticipated that sampling will be conducted for inorganics and organics in addition to monitoring.

More sophisticated trailer-mounted gas chromatograph/mass spectrometer equipment may be used to detect organic vapors in the vadose zone (soil-gas survey) as part of the RI program. Where implemented, the soil-gas survey also shall serve as an early warning system for personnel working on the surface.

When it is anticipated that air-purifying respirators are appropriate (based on the perceived risk at each site), they will be ready and available at the job site for all personnel exposed. The level of initial personnel protection will be dependent on the results of the preliminary assessment (i.e., soil-gas surveys, etc.) and ongoing site monitoring and sampling. The detailed type of respiratory protection will be specified in each PJSP.

6.2.5 Radiation

The radioactive hazards of the RI phase will be controlled by radiation work permits. At this time, the only 1100 Area RI site known to have received radioactive material in any form is the radiation contamination site (1100-5). At present, the 1100-5 site is not considered to be significantly contaminated, pending further review of documentation and other pertinent data. However, precautions should be taken whenever in the general proximity of any radiation contamination site, especially where alpha contamination may be involved.

As a general rule, any site known to have been used for disposal of miscellaneous waste will also be considered a possible radiation contamination site. This includes the disposal pits (1100-2 and 1100-3) and the Horn Rapids landfill. At a minimum, portable detection instrumentation and protective clothing will be required, along with the protective equipment and stationary sampling devices called for in the radiation work permit. Ground surveys conducted of all site surfaces have not revealed any indication of contamination.

6.2.6 Electrical Hazards

In some cases, overhead or underground electrical hazards may be encountered. To minimize these hazards, lockout, temporary rerouting, and underground excavation permits will be required for all jobs. When drilling or other large equipment is required, a buffer zone will be established around all overhead hazards, depending on the apparent power rating of the line.

6.2.7 Heat Stress

Heat stress will be a hazard common to all 1100 Area RI, especially when protective clothing must be worn during the summer. The following heat-stress control provisions shall be considered for all 1100 Area RI:

- Solar shielding (tarp/canopy)
- Early day work hours
- Ample cool water and disposable cups
- Routine partial dress-down area within the exclusion zone whenever possible
- Engineered controls (such as refrigerated vests)
- Rest breaks in accordance with the American Conference of Government Industrial Hygienists guidelines (ACGIH 87-88) (1987).

In addition, monitoring of wet bulb globe temperature levels will take place per American Conference of Government Industrial Hygienists guidelines.

6.2.8 Lighting

All field activities are anticipated to be done during daylight hours (with the possible exception of drilling, depending on demand). Adequate portable lighting will be made available for night drilling activities, and light-meter surveys will be provided. Lighting will provide at least 3 fc at the drill hole and 2 fc in the exclusion zone.

6.2.9 Noise

Noise will be a common hazard during RI. A noise survey and routine monitoring will be conducted, and adequate hearing protection will be made available to all employees (generally when noise exceeds 90 dB for extended periods of time). During those times when drill stem casing is being driven, hearing protection will be required in the exclusion zone. Appropriate hearing protection warning signs will be provided outside the exclusion zone.

6.2.10 Sanitation

General sanitation in the RI area will be maintained at all times. Good housekeeping cannot be emphasized enough as continued poor housekeeping invariably leads to accidents.

Remote areas will be provided with portable toilets and solid waste receptacles for team member use. Each command center site will also be provided with fresh potable water (changed out daily), a mechanism for hand washing, and a mobile personnel changing and shower facility wherever possible.

6.2.11 Asbestos

All OSHA, EPA, and Westinghouse Hanford standards and asbestos requirements will be followed for operations in an asbestos environment. All appropriate personnel will be trained either as asbestos workers or as "competent" workers as required by the job.

In general, personnel should be advised that remedial investigation activities are to avoid disturbance of asbestos as much as possible to minimize the airborne hazard.

6.2.12 Wind-Spread Contamination

Because of the arid climate associated with all Hanford Site waste locations, precautions must be taken regarding the potential of spreading contamination by winds. As such, all activities that involve the excavation of potential wastes may be stopped when wind speeds equal or exceed 15 mi/h. Where necessary to control dust and the resultant suspension or natural dusts and contaminants, water mists may be provided.

At each site, containment will be the primary approach to contamination control. This will be supplemented by housekeeping and access control.

6.2.13 Miscellaneous

Because indeterminate amounts of undocumented wastes were disposed of at some of the 1100 Area sites, the potential physical hazards that may be encountered during drilling are numerous. As such, drilling should not be allowed in areas known or highly suspected to contain hazardous waste containers such as drums or potentially pressurized containers.

In the case of the Horn Rapids landfill, there is evidence of some unusual disposal practices that should be discussed during pre-job safety meetings. For example, part of the area was evidently used for sewage/septic disposal, which could contain biological hazards in the form of fungus, heavy metals, and bacteria. In addition, the area was evidently used for either/or both classified-waste and tumbleweed burning. These activities could introduce metallic and radionuclide hazards from newsprint and nuclide uptake, respectively.

Other hazards that must be observed and must have protection provided for are associated with the RI itself. Heavy equipment, utility hoses, pressurized air lines, excavations near buried utilities, and sampling equipment represent tripping, pedestrian, and other hazards for which team members must be alert. Other natural hazards, such as insects and snakes, should also be discussed at safety and planning meetings. Whenever possible, engineered fixes should be provided.

6.3 PROTECTION STRATEGIES

6.3.1 Onsite Control

If radiation is involved or suspected, the SSO and radiation protection technologist are responsible for the coordination and control of access to each 1100 Area RI. A temporary exclusion zone will be established around each drilling and sampling location. A minimum of 25 ft of distance between the perimeter of the zone and the sampling/drilling location will be maintained based on criteria established by the SSO. Each zone will be marked with rope or tape and signs to clearly inform the observer of the potential hazards involved. The ground surface of the area immediately around the drill site and/or sampling location, the corridors to the site command post and the decontamination area, and the escape route will be covered with material to reduce contamination of personnel and equipment if necessary. No unauthorized personnel and only the minimum essential personnel will be allowed inside the exclusion zone.

An onsite command post and staging area, upwind of the exclusion zone, will be established for each 1100 Area RI site unless an adjacent facility or building can be used. Other considerations for the post will include proximity to utilities and access roads and proximity to sampling locations. Consideration will be given to providing a small command trailer for jobs that may last several weeks.

The command post will contain a portable air horn that can be used to alert team members to emergencies. Site-specific procedures will be developed regarding the response to this horn (for example, evacuate the area or return to the command post).

6.3.2 Responsibilities Related to Safety and Health Protection

The field team leader will be named in each PJSP and will control all activities, including the following:

- Allocation of resources necessary for health and safety programs
- Permit verification and supporting documentation
- Technical advice
- Daily communications of daily activities with the SSO
- Conflict resolution
- Emergency response decision making
- Conduct of all pre-job safety meetings.
- Stop work (order).

The SSO will be responsible for implementation of the HASP at the 1100 Area RI sites. These activities include the following:

- Monitoring of all hazards
- Determination of all protection levels and clothing and equipment needs (in conjunction with the radiation protection technologist if radiation is involved)
- Monitoring personnel job performance related to safety procedures
- Stoppage of work for safety violations
- Conduct of safety meetings
- Assistance in the conduct of pre-job safety meetings.

6.3.3 Personnel Protective Equipment

The use of cascade breathing air systems has been standard practice until the unknown organic can be accurately identified and quantified. The levels of protection for nonradioactive hazards will vary between Levels "B," "C," and "D," depending on the detection of contaminants. In general, Level "D," which will be required for all jobs, includes coveralls, substantial footwear (including high-top, leather, steel-toe boots or other material), eye protection, hard hat, gloves, rain suit, booties, hearing protection, and dosimeter (as outlined by the PJSP and checklist).

Where Level "C" is required, the hard hat, safety glasses, and dosimeter will be supplemented by chemical-resistant/surgical gloves, boots, and clothing (e.g., disposable protective coveralls), and a full-face respirator fitted with the appropriate filters (a backup escape mask and/or powered air-purifying respirator may also be required).

It is not expected that Level "A" (i.e., fully encapsulated suit or "moonsuit") with self-contained breathing apparatus will be required for any 1100 Area RI unless unforeseen situations arise. However, the use of cascade breathing air systems, with or without protective clothing (usually considered Level "B"), may be required.

In instances where both radiation and chemical hazards may be present, the radiation work permit will take precedence and will include protective strategies for both radioactive and chemical hazards. For example, organic materials and radioactive material could both occur in the Horn Rapids landfill. Therefore, the appropriate clothing may be a hard hat, chemical-resistant (or disposable) gloves, boots, clothing, and a full-face respirator fitted with both high-efficiency particulate air and organic vapor cartridges. Both types of hazard will be addressed, and a composite protection scheme will be developed.

6.3.4 Communications

A two-way radio will be manned at the command center or will be in the field team leader's possession. Any failure of radio communications will require evaluation of whether or not an evacuation of the exclusion zone will be required (given as a series of three 1-s horn blasts). Usual contact shall be maintained between the team leader and personnel in the exclusion area.

Standard hand signals will be used for all activities:

Signal	Meaning
Hand gripping throat	Out of air, can't breathe
Grip of partner's wrist or both hands around waist	Leave area immediately
Hands on top of head	Need assistance
Thumbs up	Okay, affirmative
Thumbs down	No, negative.

6.4 TRAINING REQUIREMENTS

6.4.1 Remedial Investigation Personnel

Each individual involved in field activities must have 40 h of training in hazardous material handling, encompassing the requirements of 29 CFR 1910.120 and .1200 (OSHA 1985b and 1985a respectively), to include the following:

- Employee-right-to-know and responsibilities
- Personal protective equipment (use, care, fitting, etc.)
- Hazard identification
- Radiation worker training
- Equipment operation
- Regulatory compliance
- Decontamination procedures
- Emergency response, self-rescue, first aid
- PJSP participation

- Safe sampling techniques
- Communications
- Use of sampling/drilling equipment
- Site control and management
- Hazardous material handling, storage, and transportation
- Use of field test equipment
- Communications with casual observers.

In addition, each new employee will be assigned to a more experienced employee to learn safety practices on the job. All field team participants will participate in at least 8 h of retraining annually.

6.4.2 Field Management Personnel

The SSO and the field team leader are responsible for providing detailed instructions for site-specific procedures, monitoring, equipment operations, and equipment and personnel decontamination procedures. In addition, they must complete the same training as other team members. Note that the decontamination referred to addresses the cleaning, undressing, etc. necessary to minimize health hazards as a partial protection strategy for each RI site.

These field management personnel will receive an additional 8 h of training in handling untrained site visitors, access and egress into control zones, site management, emergency notifications, instrumentation, and other topics related to RI.

All field monitoring equipment will be calibrated in accordance with the manufacturers' specifications. Field management personnel will enter all such data into field log books.

6.5 SAFETY MEETINGS AND INSPECTIONS

Prior to the start of the campaign, a formal pre-job safety meeting will be held by the project/team leader and will be attended by all team members. The HASP will be used as the basis of the PJSP. Both the HASP and the PJSP will be discussed in detail at this meeting. Verification of attendance with signatures will be required. Thereafter, "tailgate" safety meetings will be held at the start of each work day. In addition, on-the-job training will be provided to new employees through a "buddy system."

The SSO and field team leader will make routine inspections of each site and all equipment to ensure that no new safety hazards exist and to monitor activities. The frequency of monitoring/sampling conducted will be dependent on conditions being experienced and the results of preliminary assessment data analysis. When warranted, a complete dry run of each sampling activity will be provided.

6.6 MEDICAL SURVEILLANCE PROGRAM

6.6.1 Personnel

The names of key personnel who will be at risk during the RI of the 1100 Area sites will be identified in the PJSP. At a minimum, these names will include the field team leader, the SSO, subcontractor employees, the drilling supervisor, and key sampling personnel.

As required by law, personnel who routinely work in or visit an 1100 Area site will be enrolled in a formal medical surveillance program, including those people that do the following:

- Routinely (i.e., >30 d/yr) use respirators
- Are members of the Hanford Hazardous Material Response Team
- Have been or may be exposed to hazardous materials at or above prescribed OSHA or DOE exposure limits or action levels.

6.6.2 Personnel Training

All personnel actively involved in field activities during 1100 Area RI will have successfully completed the initial training required by 29 CFR 1910.120 (24 to 40 h of initial training or equivalent, depending on job hazards) (OSHA 1985b) and will be required to have a minimum of 8 h of retraining as described in Section 6.4. The SSO, field team leader, and members of management and supervision who have direct responsibility for onsite work will receive an additional 8 h/yr in management training. More importantly, each job will be preplanned by a PJSP that will be discussed in detail prior to job startup and again briefly each day that active field investigations take place.

Although the presence of radioactive materials is not anticipated in the 1100 Area, the nature of the work at the Hanford Site is such that the possibility exists. Therefore, Hanford radiation worker training will be required for RI personnel.

All personnel who work in specific areas of the Horn Rapids landfill will be trained as asbestos workers if they must handle or come in contact with the soil samples.

Because some of the 1100 Area sites are within close proximity of the public and other Hanford Site buildings, special training may be provided regarding communications with personnel who may casually observe RI activities. In some cases, a briefing to adjacent building occupants may be appropriate to offset any safety concerns the noninvolved personnel may have.

6.6.3 Medical Examinations

Prior to working at an 1100 Area RI site, key personnel must have received a baseline health assessment under the direction of a licensed physician, nurse, or occupational health professional. This assessment will consist of the following reviews, based on written documentation and discussions of the employee's duties, potential exposure levels, and protective equipment to be used:

- Personal and family medical history
- Existing hazardous material exposure profile
- Standard blood chemistry analysis (including for illicit drug usage)
- Review of any air-sampling data
- Audiometry
- Radiation exposure records
- Physician's assessment to determine fitness for duty.

Whenever questions arise regarding these reviews, additional information may be sought through additional personnel interviews. Supplemental medical examinations shall also be provided to any employees showing signs of sickness, drug abuse, or extended absences for medical reasons.

The examining physician will, in turn, provide respective Hanford contractor management with the results of the examinations and tests, an opinion regarding the employee's readiness for duty, any medical or work restrictions, and a statement that the employee has been informed of the findings of the examination. All Hanford Site contractor personnel will receive occupational health evaluations based on the DOE Site Occupational Health Contractor (Hanford Environmental Health Foundation [HEHF]) procedures and protocol.

6.6.4 Medical Records

The SSO will keep a field notebook with all pertinent information regarding field data related to environmental health information at the site. Information in the field notebook will include the following, at a minimum:

- Dosimetry and time records
- Air and exposure records
- Any observed or known toxicological risks or other hazards
- Personal observations of the job
- Approximate work locations

- Results of examinations, tests, accidents, spills, etc.
- Unusual events
- Other safety-related information.

Until the use of a more sophisticated medical tracking program becomes available, these field notebooks shall be the official medical tracking system for employees in the field. A system similar to the existing Hanford Site radioactive worker dosimetry tracking system is strongly recommended to be established for chemical and physical agents related to RI.

All medical records will be maintained in accordance with 29 CFR 1910.120 (OSHA 1985b) and DOE requirements.

6.7 EMERGENCY INFORMATION

6.7.1 General Information

In case of an emergency, notification will be made through the "811" emergency response number. Because the 1100 Area sites are not in the same emergency response jurisdiction, informing the operator of the location of the problem is important. For example, the Horn Rapids landfill is just north of the Richland city limits; therefore, the Hanford Fire Department/ambulance and Hanford Patrol would respond to any emergency (depending on the severity of the emergency, a cooperative response is also possible). Conversely, the other 1100 Area RI sites are within the city limits; therefore, the Richland Fire and Police Departments would be the first to respond. The dispatcher at the Hanford Fire Department will be notified where work is to be performed at a site before that work begins.

Emergency Telephone Numbers are as follows:

Hanford Site emergency response	811
Richland emergency services	911
PNL emergency response	375-2400
Kadlec Medical Center/Emergency Decontamination Facility	946-4611
Poison Control Center	800-542-5842
National Response Center	800-424-8802
Chemical Transportation Emergency Center	800-424-9300
Chemical Emergency Preparedness Program hotline (SARA Title III information)	800-535-0202
Resource, Conservation, and Recovery Act/Superfund hotline	800-424-9346
Toxic Substances Control Act hotline	202-554-1404
Safe Drinking Water Act	800-426-4791
Westinghouse Hanford Safety--Gordon Meade	373-3948
Westinghouse Hanford Site Safety Officer--Jim Mohatt	373-5566
PNL Safety--Tom McLaughlin	376-0499

6.7.2 Emergency Procedures

Communications will be maintained during all onsite field activities by two-way radio contact. If an emergency occurs, such as fire or explosion, all onsite personnel should exit the site in an upwind direction and assemble in a predesignated area. All emergency response actions for each job will be covered in the tailgate meeting with the PJSP. If an onsite emergency occurs, the procedures that follow should take place.

- Upon notification of an injury in the exclusion zone, the emergency signal of three 1-s horn blasts will be sounded. All site personnel will assemble at the decontamination line. If the injured persons cannot walk to the decontamination line, they will be removed to the decontamination line only if moving them is required to prevent greater risk from the contaminants than would occur from moving the individual prior to arrival of emergency personnel. The decision to move an injured individual will be based on an evaluation of the injury and the contamination hazard. The SSO and the field team leader should evaluate the nature of the injury and the extent of decontamination possible prior to movement of the injured person to the support area. Appropriate first aid should be initiated, and an ambulance summoned, if required. No person should reenter the exclusion zone until the cause of the injury is determined and measures are taken to prevent recurrence.

- Upon notification of an injury in any support area, the SSO and the field team leader will assess the nature of the injury. If the cause of the injury or loss of the injured person does not affect the performance or safety of site personnel, operations may continue, with initiation of first aid and summoning of ambulance, if required. If the injury increases the risk to others, the emergency signal of three 1-s horn blasts will be sounded and all site personnel shall move to the decontamination area for further instructions. Activities onsite will stop until the added risk (if any) is evaluated and reduced to an acceptable level.

- Upon notification of a fire or explosion onsite, the emergency signal of three 1-s horn blasts will be sounded and all site personnel will assemble at the decontamination line. The fire department will be notified by the SSO and all personnel will move to a safe distance from the involved area. Again, based on the individual tailgate meetings, a decision to send all personnel immediately out of the exclusion area may be an option.

- If any worker experiences a failure of protective equipment that affects the protection factor, that person and his or her buddy shall immediately leave the exclusion zone. Reentry shall not be permitted until the equipment has been repaired or replaced or the conditions leading to the problem are adequately evaluated and corrected.

- If onsite equipment fails to operate properly, the SSO and the field team leader shall be notified and then determine the effect of the failure on continuing operations. If the failure affects the safety of personnel or prevents completion of the work plan tasks, all personnel shall leave the exclusion zone until the necessary repairs are made.

- In the event that an emergency situation prevents exiting the exclusion zone by way of the decontamination area, exit the exclusion zone in any direction, preferably upwind.

- If an injury to a worker involves chemical exposure, the following first aid procedures are to be instituted as soon as possible:

  - Eye Exposure. If contaminated solid or liquid gets into the eyes, wash eyes immediately with an emergency eye wash using large amounts of water and lifting the lower and upper lids occasionally (an emergency eye wash station will be provided in the field). **Obtain medical attention immediately**.

  - Inhalation Exposure. If a person inhales large amounts of organic vapor, that person should be moved to fresh air at once. If breathing has stopped, perform artificial respiration. If breathing and heart have both stopped, perform cardiopulmonary resuscitation (CPR). **Obtain medical attention immediately**. Keep the person warm and at rest until medical help arrives.

  - Skin Exposure. If contaminated solids or liquids get on the skin, promptly use the deluge water unit, then wash contaminated skin using soap or mild detergent and water. If solids or liquids penetrate through the protective clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. **Obtain medical attention immediately if symptoms warrant**.

  - Ingestion. If contaminated solid or liquid has been swallowed, immediately **obtain medical attention and call the Poison Control Center**. In these situations, if 811 is not notified, the person should be taken to the nearest first aid station.

- Although radiological exposures are not anticipated in the 1100-EM-1 operable limit, the nature of work at the Hanford Site is such that the possibility exists. If any form of radioactive contamination of either personnel or equipment is detected or suspected by the radiation protection technologist, SSO, field team leader, or the affected individual, then appropriate decontamination procedures and immediate first aid, if necessary, will be administered by a trained radiation protection technologist. As a precautionary measure, the radiological action and warning levels will be detailed in each separate PJSP issued for each individual site.

6.8 NEEDED DOCUMENTS

The PJSP provides specific safety procedures and requirements for each activity at each RI site. These are developed on an individual basis and will be available at the work site. These documents will address, at a minimum, the following:

- Site- and activity-specific health and safety issues
- Standard operating procedures
- Personnel requirements
- Standards on protective equipment and risk mitigation
- Site-specific limits, warning levels, instrument requirements, and measurement frequency for air and exposure monitoring
- Routine and emergency decontamination procedures
- Site-specific emergency procedures.

Safe work practices that can be generally applied to all RIs are the following.

- Hard hats, safety glasses, and steel-toe boots will be worn when inside the exclusion zone.
- Eating, drinking, chewing gum or tobacco, or smoking will be prohibited in the exclusion zone.
- No facial hair that interferes with face-to-mask seal of respirators or self-contained breathing apparatus will be allowed.
- No contact lenses will be worn.
- Personnel shall avoid direct contact with contaminated materials unless necessary for sample collection or required observation. Remote handling of casing, auger flights, etc., will be practiced whenever practical.
- Personnel not involved in operation of the cable-tool drill rig or monitoring activities shall remain a safe distance from the rig as indicated by the field team leader.
- Following decontamination or whenever leaving the exclusion zone, personnel should wash face and hands thoroughly.
- At the end of each work day or each job, disposable clothing shall be removed and placed in drums or plastic-lined "rad" boxes. Clothing that can be cleaned shall be sent to the Hanford Laundry.

- Individuals are expected to thoroughly shower as soon as possible after leaving the job site if directed to do so by the radiation protection technologist, site safety officer, or field team leader.

- Personnel shall use the "buddy system" at all times while operating in the exclusion zone.

- Personnel shall maintain a high level of awareness of the limitations in mobility and dexterity, and of the visual impairment inherent in the use of Level "B" and Level "C" personal protection equipment.

- All drilling operations personnel will be aware of the position of every person in regard to rotating equipment, cat heads, U-joints, etc., and will be extremely careful when assembling, lifting, and carrying auger flights or drill pipe to avoid pinch point injuries and collisions.

- Tools and equipment will be kept off the ground whenever possible to avoid tripping hazards and the spread of contamination.

- The "buddy system" will be used for all manual lifting.

- All team personnel are required to attend a pre-job safety meeting prior to the start of the campaign.

- A mandatory "tailgate" meeting will be conducted prior to each hole-drilling operation.

- All work operations onsite shall cease at sunset, unless the entire control zone is adequately illuminated with artificial lighting. A new tour (shift) will man the rig after completion of each shift.

- Requirements of general regulations and practices for radiation work shall be followed for all work involving radioactive materials or radioactive contamination.

- Team members will attempt to minimize truck tire disturbance of all stabilized sites.

- If safety concerns arise during the course of the field study that are not satisfactorily addressed by this safety plan or the subsequent pre-job safety plan, work will be stopped until the site safety officer and the field team leader evaluate and resolve the concerns. Employees are encouraged to bring up any safety concerns to the site safety officer or field team leader.

- Under most circumstances, crews working on a hazardous waste site will work no longer than an 8-h shift.

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7.0 FEASIBILITY STUDY PLAN

This section describes the process by which the FS is conducted to identify and evaluate remedial alternatives for an individual location within the 1100-EM-1 operable unit. The identification of appropriate remedial responses can be divided into three phases. In Phase 1, the RI findings on the nature and extent of contamination are used to perform a baseline risk assessment. This risk assessment is used to evaluate the impacts of a no-action alternative. During the FS, additional ARARs and to-be-considered (TBC) requirements to those listed in the RI are defined and evaluated to determine what additional technology-related ARARs should be addressed with respect to their implementation. If risks are not identified in baseline no-action assessment, then further analyses will not be performed. If potential adverse risks are identified, the FS will proceed with identification of treatment technologies and formulation of remedial alternatives. In Phase 2 of the FS, remedial alternatives are screened to eliminate those that are inappropriate. A detailed evaluation and comparative analysis of the alternatives passing the screening phase is conducted in Phase 3. These analyses provide the basis for selection of the remedial alternative during the ROD process.

In the Phase 1 FS, remedial alternatives are developed by identifying potentially appropriate medium-specific general response actions, remedial technologies within each general response action category, and a representative process option for each technology. Alternatives, which encompass a range of appropriate waste management options, are then assembled by combining remedial technologies to create potential remedies for each waste location within the operable unit.

Alternatives are screened in the Phase 2 FS to narrow the list of potential remedies that will be evaluated in further detail. The screening procedure is designed to ensure that the most promising alternatives are retained and that a range of waste management options--to the extent practicable--is preserved.

The alternatives that pass the screening phase are analyzed in detail and compared during the Phase 3 FS. Comparisons conducted during the third phase provide the basis for selection of an appropriate remedy by project decision-makers during the subsequent ROD process.

The FS for the 1100-EM-1 operable unit will be conducted concurrently with the RI in an interactive manner. The results of the RI will provide information needed to evaluate remedial alternatives in the FS, and the results of the initial phases of the FS will, in turn, provide focus and define data needs for the RI. In addition, the first two phases of the 1100-EM-1 FS will be performed as a single task, so that the alternatives screening process is initiated immediately after the alternatives are developed.

Before remedial alternatives development, remedial action objectives are defined, formulated on promulgated environmental regulatory requirements and an analysis of the specific environmental risks posed by contaminant release. This is an iterative process that is begun during RI/FS scoping and continues throughout the project. Section 7.1 presents a preliminary evaluation of cleanup objectives and requirements for the 1100-EM-1 operable unit.

7.1 CLEANUP OBJECTIVES AND REQUIREMENTS

To identify appropriate potential remedial technologies, remedial action goals must be defined. Federal, State, and local regulations and guidelines are important factors in the determination of remediation goals. According to the CERCLA, legally applicable or relevant and appropriate requirements must be considered in selecting waste cleanup remedies. These include Federal and State environmental standards, criteria, requirements, limitations, statutes, and regulations. This section of the FS plan provides a brief, preliminary overview of proposed ARARs that will serve as the basis for developing specific RA objectives. These objectives will in turn be used to identify appropriate potential remedial alternatives for the 1100-EM-1 operable unit.

Regulatory requirements, standards, and guidance are important to consider in assessing the acceptability of a remedial alternative at a particular site. These requirements serve to guide project engineers in terms of the level of cleanup and technology performance required and may make obvious the advantage of one remedial technology over another. An understanding of potential ARARs can also help determine data collection and site characterization needs and direct the sampling and evaluation programs for a site. Identifying data collection needs and restrictions on remedial technology options streamlines the processes for site characterization and remedy screening/selection.

Regulation-driven requirements are only one of a variety of important factors that need to be considered in the full cleanup process. Some of the regulatory requirements that need to be considered throughout the FS process include the following:

- Identification of potential ARARs and TBC regulatory guidance
- Development of contaminant-specific cleanup goals where ARARs do not exist
- Definition and development of RA objectives
- Identification of site-specific locations subject to remediation in accordance with the RA objectives.

The following sections of the feasibility study plan present a brief discussion of these four requirements. The identification of ARARs and the development of regulatory guidance for technology screening and remediation is an interactive and iterative process. The following material is intended to describe the concepts and provide a starting point for that process for the 1100-EM-1 operable unit.

7.1.1 Preliminary Identification of Applicable or Relevant and Appropriate Requirements

The EPA's Interim Guidance on Compliance with Applicable or Relevant and Appropriate Requirements (EPA 1987c) describes the following three types or classifications of ARARs:

- Chemical-specific requirements that set health or risk-based concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants. Examples include maximum contaminant levels under the Safe Drinking Water Act of 1974 and national ambient air quality standards under the Clean Air Act of 1977

- Action-specific requirements that set controls or restrictions on particular kinds of activities related to management of hazardous substances, pollutants, or contaminants. Examples include RCRA regulations for closure of hazardous waste storage or disposal facilities, and Clean Water Act of 1977 pretreatment standards for discharge to publicly owned treatment works

- Location-specific requirements that set restrictions on activities with regard to the characteristics of a site or its surrounding environment. Examples include Federal and State siting laws for hazardous waste facilities.

The EPA interim guidance also states that standards or requirements contained in nonpromulgated advisories or guidance documents issued by Federal or State governments or agencies do not have the status of ARARs. However, they may be considered or used as reference criteria in determining the necessary level of cleanup for protection of public health or the environment, and are referred to as "to be considered" (TBC). When no ARARs exist or existing ARARs are not sufficient to be protective, health advisory levels such as reference doses or carcinogenic potency factors should be identified to ensure protectiveness of a remedy, or alternative criteria for cleanup may be developed as described in Section 7.1.2 of this work plan.

The broad array of potential chemical-specific ARARs for the 1100-EM-1 operable unit are identified in Tables 7-1 and 7-2. Explanatory notes for the material presented in these tables are contained in footnotes to the tables. Additional guidance values that may be relevant to identifying remediation alternatives (TBCs) are also included in the tables. The TBCs have been included to provide information for developing RA objectives when no actual ARARs exist for a particular contaminant. The columns for EPA drinking water health advisories and toxicity data on Table 7-1, for example, fall under this description. Action- and location-specific potential ARARs have not yet been developed as part of this work plan. Action-specific ARARs are generally specific to technologies or technology types; thus, they should be developed after initial technology screening during the Phase 1 FS. Location-specific ARARs, such as those under cultural resource and wildlife protection statutes, must also be developed.

Table 7-1. Potential Applicable or Relevant and Appropriate Requirements and Other Guidance. (sheet 1 of 4)

	Federal air[a] quality standards	Federal and State[b] drinking water standards			CERCLA[c] reportable quantities (lb)	Toxicity data[d]					TSCA[g]	EPA drinking water health advisories[h,i]						RCRA and WAC waste designation and concentration limits[j]		
						RfD[e] concentraion		RSD[f] concentration				1 d	10 d	Longer term		Lifetime	Reference concentration for potential carcinogen (ng/L)			
		MCL (mg/L)	MCLG (mg/L)	SMCL (mg/L)		Soil (mg/kg)	Water (µg/L)	Soil (mg/kg)	Water (µg/L)	Air (µg/m³)		10-kg infant (µg/L)	10-kg infant (µg/L)	10-kg infant (µg/L)	70-kg adult (µg/L)	70-kg adult (µg/L)		Toxicity	EP toxicity (mg/L)	Contaminant levels in groundwater (mg/L)
Halogenated and nonhalogenated hydrocarbons																				
Benzene	(b)	0.005	0	--	1,000	--	--	12.2	1.22	0.122	--	233	233	NA	NA	NA	0.35	C	--	--
Xylene	--	--	0.44[k]	--	1,000	--	--	--	--	--	--	12,000	7,800	7,800	27,300	2,200	NA	C	--	--
Toluene	--	--	2.0[k]	--	1,000	100,000	10,000	--	--	--	--	18,000	6,000	--	--	10,800	NA	C	--	--
Methyine chloride	--	--	--	--	1,000	21,000	2,000	47	4.7	0.25	--	--	--	--	--	--	--	C	--	--
TCE, trichloroethylene	--	0.005	0	--	1,000	--	--	32	3.2	0.27	--	--	--	--	--	--	2.8	C	--	--
Carbon tetrachloride	--	0.005	0	--	5,000	200	20	2.7	0.27	0.027	--	4,000	160	71	250	--	0.3	D	--	--
Tetrachloroethylene	--	--	0[k]	--	1.0	40,000	3,000	69	6.9	0.14	--	--	34,000	1,940	6,800	--	0.7	X	--	--
1,1,1 trichloroethane	--	0.20	0.20	--	1,000	40,000	3,000	--	--	--	--	140,000	35,000	35,000	125,000	1,000	22,000	C	--	--
TCA, trichloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--
Selected chemical constituents in the 1100 Area operable unit																				
Mercury	≤ 2,300 g/24h[l] ≤ 3,200 g/24h	0.002	0.003	--	1.0	100 (methyl)	10 (methyl)	--	--	--	--	--	--	--	--	5.5	NA	X	0.2	0.002
Chromium	--	0.05	0.12	--	1.0	400,000 (trivalent) 2,000 (hexavalent)	40,000 (trivalent) 2,000 (hexavalent)	--	--	0.000085 (hexavalent)	--	1,400	1,400	240	840	170	NA	X	5.0	0.05
Arsenic	< 2.5 Mg/yr[m] < 0.4 Mg/yr	0.05	0.05	--	--	--	--	0.0222	0.00222	0.000232	--	50	50	50	50	50	0.0022	X	5.0	0.05
Lead	1.5 µg/m³	0.05	0.02	--	--	--	--	--	--	--	--	--	--	20 µg/d	20 µg/d	20 µg/d	0.031	X	5.0	0.05
Nitrate[n]	--	10	10	--	--	--	--	--	--	--	--	10,000 (4 kg) 1.1 x 10⁵ (10 kg)	10,000 (4 kg) 1.1 x 10⁵ (10 kg)	--	--	10,000	NA	--	--	10.0
Sulfate	--	--	--	250	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ethylene glycol	--	--	-	--	--	--	--	--	--	--	--	19,000	5,500	5,500	19,250	--	NA	D	--	--
PCBs	--	--	0.0	--	10.0	--	--	0.045	0.0045	--	Restricted access[g] area: 25 p/m Nonrestricted access area: 10 p/m	--	--	--	--	--	--	A	--	--
Di-N-Octyl phthalate	--	--	--	--	5,000	--	--	--	--	--	--	--	--	--	--	--	--	D	--	--
Bis-(2-Ethylhexyl) phthalate	--	--	--	--	1.0	6,000	700	--	--	--	--	--	--	--	--	--	--	X	--	--

Table 7-1. Potential Applicable or Relevant and Appropriate Requirements and Other Guidance. (Sheet 2 of 4)

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
EP = Extraction procedure.
EPA = U.S. Environmental Protection Agency.
MCL = Maximum contaminant level.
MCLG = Maximum contaminant level goal.
RCRA = Resource Conservation and Recovery Act.
RfD = Reference dose.
RSD = Risk specific dose.
SMCL = Secondary maximum contaminant level.
TSCA = Toxic Substances Control Act.
WAC = Washington Administrative Code.

[a]This column outlines the standards identified under the Clean Air Act of 1977 and implementing regulations (EPA 1981, 1982). The basic purpose of the Clean Air Act is to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Its implementing regulations are found in EPA regulations (1981, 1982). The State standards are available in the Washington Administrative Code (Ecology 1972) and General Regulation 80-7 of the Benton-Franklin-Walla Walla Counties Air Pollution Control Authority (1980). These regulations contain no numerical standards for and of the listed constituents in the 1100-EM-1 operable unit.

Mercury -- The mercury standards from 40 CFR 61.52(a) and (b) (EPA1982) present standards for emissions to the atmosphere from (1) mercury ore processing facilities and mercury cell chlor-alkali plants and (2) sludge incineration or sludge drying plants, respectively. For either of these types of plants, mercury emissions shall not exceed the given numerical standard in any 24-h period.

Arsenic -- The arsenic standards given in 40 CFR 61.162(a) and (b) (EPA 1982) are specific to uncontrolled emissions from glass-melting furnaces. These uncontrolled arsenic emissions must be less than the given numerical standard during any 1 yr.

Lead -- The lead standard is from 40 CFR 50.12 (EPA 1981). The pollutant is measured by a maximum arithmetic mean averaged over a calendar quarter.

Benzene -- The benzene standard given in 40 CFR 61.110 (EPA 1982) is specific to benzene leaks from pumps, compressors, pressure-relief devices, sampling connections, systems, open-ended valves or lines, valves, flanges and other connectors, product accumulator vessels, and control devices or systems. Standards and repair time frames relating to failure of seals, valves, and other leak control systems are available in the regulations for each piece of equipment listed above. As such, these standards and requirements have no ready applicability to the source of benzene in the 1100 Area operable unit.

[b]Federal and State drinking water standards: MCLs, MCLGs, and SMCLs. The purpose of the Safe Drinking Water Act of 1974 and its 1986 amendments is to protect public health by protecting drinking water sources. The Federal implementing regulations for the Act include the National Primary and Secondary Drinking Water Regulations in 40 CFR 141 and 143 (EPA 1986a and 1987e, respectively). The State of Washington is authorized to administer the public water supply regulations set forth under the Act. These State implementing regulations are found in WAC 248-54, (Ecology 1983).

The primary drinking water standards are set in two stages for each contaminant: a maximum contaminant level goal (MCLG), which is the level at which no adverse health-based effects would arise with a margin of safety, and a maximum contaminant level (MCL), which sets enforceable levels as close to the MCLG as is feasible, taking cost, lab capability, and other factors into account. These standards are set nationally and are enforced principally by the states. The secondary maximum contaminant levels (SMCL) are given for contaminants that may adversely affect the odor or appearance of water and serve as guidelines to the states (as such, they are not enforceable).

The MCL and SMCL values for the selected constituents in the table are the same in both the Federal and State regulations, while the MCLGs are strictly Federal guides. The MCL for nitrate is for measuring nitrate as nitrogen.

[c]The basic purpose of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) is to provide funding and enforcement authority both for responding to releases of hazardous substances to the environment and for cleaning up abandoned or inactive waste sites (i.e., spills, discharges, etc.). The implementing regulations for this Act are found in 40 CFR 300 and 302 (EPA 1985f and 1985a, respectively). In EPA (1985a) Table 302 4, there is a list of CERCLA-defined hazardous substances and their reportable quantities. The presence of these substances in quantities equal to or greater than their reportable quantities requires notification to the National Response Center and subsequent removal, remediation, or both.

[d]EPA (1987f).

[e]RfD = reference dose, an estimate of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Soil ingestion assumes an intake rate of 0.2 g/d for a 70-kg adult; water ingestion assumes an intake rate of 2 L/d for a 70-kg adult.

[f]RSD = risk specific dose corresponding to excess lifetime cancer risks of 10^{-6} for Class A and B carcinogens or 10^{-5} for Class C carcinogens. Soil ingestion assumes an intake rate of 0.2 g/d for a 70-kg adult; water ingestion assumes an intake rate of 2 L/d for a 70-kg adult; air inhalation assumes an intake of 20 m^3/d for a 70-kg adult.

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Table 7-1. Potential Applicable or Relevant and Appropriate Requirements and Other Guidance. (Sheet 3 of 4)

[g]Toxic Substances Control Act of 1976 (TSCA)--PCB Cleanup Policy. The purpose of the Act is to identify and evaluate potential hazards from chemical substances and to regulate the production, use, distribution, and disposal of these substances. Implementing regulations for this Act include Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (EPA 1984). Subpart G is entitled "PCB Spill Cleanup Policy" (hereafter referred to as "Policy") and was originally published as a policy rule. The Policy establishes measures that EPA considers to be adequate for the cleanup of PCB contamination from activities regulated under the TSCA.

The scope of this Policy states that "...spills which occurred before the effective date of this policy [July 1, 1987] are to be decontaminated to requirements established at the discretion of EPA, usually through its regional offices" (EPA 1984). This section excludes spills directly into surface waters, drinking waters, sewers, grazing lands, and vegetable gardens from application of final numerical cleanup standards. For all other spills, EPA generally expects the final cleanup standards contained in the Policy to apply. Depending on the circumstances of a spill, EPA retains the flexibility to require or allow different or more stringent cleanup requirements because of site-specific considerations such as the following:

- Additional routes of exposure
- Factors that may mitigate exposures and risk or make cleanup to the standards impracticable (EPA 1984).

The EPA will apply this flexibility if the responsible party demonstrates that compliance to the cleanup level is clearly unwarranted because of the following:

- Risk-mitigating factors
- Impracticability at a particular site
- Site-specific characteristics that make the costs of cleanup prohibitive (EPA 1984).

Section 761.125, (EPA 1984), which contains the requirements for PCB spill cleanup, is divided into two parts: requirements for cleanup of spills involving less than 1 lb of PCBs by weight and requirements for cleanup of spills involving 1 lb or more of PCBs by weight. Discussions of both are presented below.

Spills Involving Less Than One Pound of PCBs by Weight -- For spills involving less than 1 lb of PCBs, all solid surfaces (metals, glass, wood, asphalt, etc.) must be double washed/rinsed and all soil must be excavated within the spill area (i.e., visible traces of soil and a buffer of one lateral foot around the visible traces). The ground must be restored to its original configuration by back-filling with clean soil (i.e., containing less than 1 p/m of PCBs). A double wash/rinse involves cleansing solid surfaces two times with an appropriate solvent or other material in which the PCBs are at least 5% soluble (by weight)

Spills Involving One Pound or More of PCBs by Weight -- Decontamination requirements for these spills are dependent on the following two types of areas:

- Restricted Access Areas. Areas other than electrical substations that are at least 0.1 km from a residential/commercial area and limited by man-made barriers (e.g., fences and walls) or substantially limited by naturally occurring barriers such as mountains, cliffs, or rough terrain (40 CFR 761.123) (EPA 1984).
- Nonrestricted Access Areas. Areas other than restricted access, outdoor electrical substations, and other restricted access areas. These areas include residential/commercial areas as well as unrestricted access rural areas (areas of low-density development and population where access is uncontrolled by either man-made barriers or naturally occurring barriers) (40 CFR 761.123) (EPA 1984).

Cleanup requirements for these two types of areas are available for various surfaces and soil with only those standards for soil being given here.

For restricted access areas, soil that is contaminated by a spill involving 1 lb or more of PCBs must be cleaned to 25 p/m of PCBs by weight [40 CFR 761.125(c)(3)(v)] (EPA 1984).

For nonrestricted access areas, soil that is contaminated by a spill involving 1 lb or more of PCBs must be cleaned to 10 p/m of PCBs by weight provided that the soil is excavated to a minimum depth of 10 in. The excavated soil must be replaced with clean soil (i.e., containing less than 1 p/m of PCBs), and the spill site will be restored (e.g., replacement of turf) [40 CFR 761.125(c)(4)(v)] (EPA 1984).

[h]These data are guidance material found in the EPA guidance document (EPA 1986b). As such, they cannot be ARARs, but may be relevant.

[i]EPA Drinking Water Health Advisories. In the Superfund Manual, EPA provides guidance in the form of nonregulatory health advisories for various chemicals found in drinking water. This guidance presents health advisories that are based on the concentrations of contaminants in drinking water at which no adverse effects to human health would be expected to occur. A margin of safety is factored in to protect sensitive members of the population such as infants. Because the data are from guidance material, they cannot produce potential ARARs due to the definition of ARAR in Interim Guidance on Compliance with Applicable or Relevant and Appropriate Requirements, (EPA 1987c). However, the data may be considered to be necessary in ensuring protectiveness and may be appropriate for use in specific alternatives.

One-Day and Ten-Day Health Advisories -- The quantities in both of these categories are calculated for a 10-kg child (a one-year old infant) assumed to drink 1 L of water per day.

Longer-Term Health Advisories (Several Months to Several Years of Exposure) -- The quantities in this category are calculated for both a 10-kg child and a 70-kg adult assumed to drink 1 L and 2 L of water per day, respectively

Lifetime Health Advisories -- The quantities in this category are calculated for a 70-kg adult assumed to drink 2 L of water per day.

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Table 7-1. Potential Applicable or Relevant and Appropriate Requirements and Other Guidance. (Sheet 4 of 4)

Reference Concentration for Potential Carcinogen -- The quantities in this category, if found in drinking water, are to be associated with a projected upper 95% confidence limit excess lifetime cancer risk of 10^{-6}. Comparing these values to actual concentrations in drinking water can provide an indication of the magnitude of potential carcinogenic risk.

[j]Toxicity, EP Toxicity, and Concentration Limits in Groundwater (RCRA and WAC). The Resource Conservation and Recovery Act of 1976 (RCRA) regulates the management of hazardous waste from generation to disposal. With the exception of the 1984 amendments to RCRA (Hazardous and Solid Waste Amendments of 1984), authority to implement RCRA has been delegated to the State of Washington. The State of Washington Hazardous Waste Management Act (1976) and its implementing regulations (Ecology 1987a) set forth the State requirements for regulating hazardous waste.

Toxicity Column. This column presents categories representing the toxicity of each identified chemical constituent. The categories, in descending order of toxicity, are X, A, B, C, and D. The quantitative difference between each category is a factor of 10 (e.g., X is 10 times more toxic than A, and 100 more than B. A is 10 times more toxic than B, etc.). The toxicities, when used in conjunction with the weight percent of each toxic constituent present in a waste mixture, can be used to calculate the equivalent concentration and determine if the waste mixture will be designated as a dangerous or extremely hazardous waste (WAC 173-303-084) (Ecology 1987a). The procedures used to calculate equivalent concentrations and to designate a waste are available in WAC 173-303-9903 (Ecology 1987a). Toxicity classifications for some constituents are found in the fourth column of the discarded chemical products list in Ecology (1987a). In addition, the requirements of RCRA (1976) specify that the constituents in mixtures must also be checked against the toxicities given in column 7 of Table 302.4 of EPA (1985a) and those given in the National Institute for Occupational Safety and Health (NIOSH) Registry of Toxic Effects of Chemical Substances [WAC 173-303-084 (2)] (Ecology 1987a). The toxicity of ethylene glycol was obtained from data in the NIOSH Registry. The toxicities of the other constituents in the column were taken from Table 302.4 of EPA (1985a). Trichloroethane was assigned to toxicity category "X" because trichloroethane is assumed to be a mixture of 1,1,1 trichloroethane (toxicity C) and 1,1,2 trichloroethane (toxicity X). For situations in which insufficient information on constituents has been provided, the more stringent toxicity assignment is used.

After a waste has been designated as nonhazardous, dangerous, or extremely hazardous, disposal options can be evaluated. For example, some disposal methods will not be allowed for extremely hazardous waste. As of February 5, 1988, new land disposal restrictions (Ecology 1987a) became effective that prohibit land disposal of various classes of waste.

In addition to toxicity, wastes and waste mixtures can be designated as dangerous or extremely hazardous based on: how the waste was discarded (WAC 173-303-081), the sources of the waste (WAC 173-303-082), persistence and carcinogenic properties (WAC 173-303-084), characteristics of the waste (WAC 171-303-090), and dangerous waste criteria (WAC 173-303-101, 102, 103) (all Ecology 1987a). For example, a waste is considered persistent and dangerous if more than 100 kg are present and the total organic halogen concentration exceeds 0.01% by weight.

EP Toxicity Column--The values presented in this column are available in the EP Toxicity List in WAC 173-303-090 (Ecology 1987a). The values apply to the liquid extract of a waste and not to the actual waste and result in the designation of a waste as dangerous or extremely hazardous.

Concentration in Groundwater Column--This column presents concentration limits for constituents that must not be exceeded in the groundwater underlying a hazardous waste management area.

[k]These are proposed MCLGs that have not yet been finalized (EPA 1985e).

[l]These standards are for mercury ore processing facilities and mercury cell chlor-alkali plants, and sludge incineration or sludge drying plants, respectively.

[m]These standards are for uncontrolled emissions from existing and new glass melting furnaces, respectively, and are in units of megagrams per year.

[n]The 1- and 10-d health advisories for nitrate are given for both a 4-kg newborn and a 10-kg infant.

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Table 7-2. Potential Applicable or Relevant and Appropriate Requirements for Selected Radionuclides in the 1100 Area Operable Unit.

Reportable quantities	CERCLA[a] reportable quantities (Ci)	Federal and State[b] drinking water standards (pCi/L)	Federal air quality standards[c]	10 CFR 20 (NRC 1979) emission limit concentrations in air and water above natural background[d]				Environmental radiation protection standards for radioactive waste disposal[e]	
				Air (μCi/mL)		Water (μCi/mL)			
				Soluble	Insoluble	Soluble	Insoluble	40 CFR 191	40 CFR 193
Gross alpha	--	15	(f,c)	--	--	--	--	--	--
Gross beta	--	< 50[g]	(c)	--	--	--	--	--	--
Gross gamma	--	--	(c)	--	--	--	--	--	--
Americium-241	10.0	--	(c)	2×10^{-13}(d)	4×10^{-12}(d)	4×10^{-6}(d)	3×10^{-5}(d)	100 Ci/unit of waste[e]	--
Cesium-137	0.01	--	(c)	2×10^{-9}(d)	5×10^{-10}(d)	2×10^{-5}(d)	4×10^{-5}(d)	1,000 Ci/unit of waste[e]	--
Dose equivalents	--	4 mrem/yr[g]	Whole body: 25 mrem/yr Critical organ: 75 mrem/yr Alternate Standards Continuous exposure: 100 mrem/yr Noncontinuous exposure: 500 mrem/yr (c)	--	--	--	--	Whole body: 25 mrem/yr Critical organ: 75 mrem/yr Alternate Standards Continuous exposure: 100 mrem/yr Noncontinuous exposure: 500 mrem/yr (e)	25 mrem[h] --(h)

[a]Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) radionuclide reportable quantities. The reportable quantity for radionuclides was originally set at 1 lb. The U.S. Environmental Protection Agency (EPA) recognized that this reportable quantity may not be appropriate because smaller quantities of radionuclides may present a substantial threat to public health, welfare, or the environment. As a result, EPA proposed a rule adjusting the reportable quantities for radionuclides in terms of curies rather than pounds (52 FR 8172, March 16, 1987 [EPA 1987b]). The proposed reportable quantities for ^{241}Am and ^{137}Cs are set at 0.01 Ci and 10 Ci, respectively.

[b]Federal and State Drinking Water Standards--Radionuclide maximum contaminant levels (MCL). The Federal and State regulations under the Safe Drinking Water Act set forth radionuclide MCLs in 40 CFR 141.15-141.16 (EPA 1986a) and WAC 248-54-175(8) (Ecology 1983), respectively. The Federal regulations specify radionuclide MCLs for community water systems as follows:

- The MCL for combined ^{226}Ra and ^{228}Ra is 5 pCi/L.
- The MCL for gross alpha particle activity (including ^{226}Ra but excluding radon and uranium) is 15 pCi/L.
- The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr.
- Except for tritium and ^{90}Sr, the concentration of man-made radionuclides causing 4 mrem total body or organ dose equivalent shall be calculated on the basis of a 2-L/d drinking water intake. If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any organ shall not exceed 4 mrem/yr.

For tritium and ^{90}Sr, the average annual concentrations assumed to produce a total body or organ dose of 4 mrem/yr are 20,000 pCi/L and 8 pCi/L, respectively.

The State MCL for combined ^{226}Ra and ^{228}Ra is the same as the Federal MCL; however, the State also sets an MCL for ^{226}Ra alone (3 pCi/L) and excludes only uranium from the MCL for gross alpha activity (15 pCi/L). The 4-mrem/yr limit on which the MCL for beta and gamma activity is based is the same as the Federal limit. However, the State regulations state that compliance with this limit may be assumed if the average annual concentrations for gross beta activity, tritium, and ^{90}Sr are less than 50 pCi/L, 20,000 pCi/L, and 8 pCi/L, respectively. If both tritium and ^{90}Sr are present, the sum of their annual dose equivalents to bone marrow may not exceed 4 mrem/yr.

[c]Federal Air Quality Standards--Air Standards for Radionuclides. The EPA's National Emission Standards for Hazardous Air Pollutants (40 CFR 61) (EPA 1982) include, in Subpart H, a standard for air emissions at U.S. Department of Energy (DOE) facilities. (The Subpart does not apply to facilities regulated under 40 CFR 190, 191, or 192 [EPA 1977, 1985b, 1983]) The State of Washington has an emission standard in WAC 173-480-070 (Ecology 1986). Each standard limits the air emission of radionuclides to those amounts that cause a dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to the critical organ of any member of the public (40 CFR 61.92; WAC 173-480-040) (EPA 1982; Ecology 1986). Doses due to ^{220}Rn, ^{222}Rn, and their respective decay products are excluded from these limits.

To determine compliance with these standards, emissions shall be determined and dose equivalents shall be calculated using sampling procedures and dose conversion models that are approved by the EPA and the Washington Department of Social and Health Services. Compliance will be determined by calculating the dose to members of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public may be (WAC 173-480-070) (Ecology 1986) or where any member of the public resides or abides (40 CFR 61.93) (EPA 1982).

If a facility exceeds the above values, DOE may apply for an alternate emission standard under the Federal regulations. The EPA will establish an appropriate emission standard that will ensure that no member of the public being exposed to emissions from the facility will receive a continuous exposure of more than 100-mrem/yr effective dose equivalent and a noncontinuous exposure of more than 500-mrem/yr effective dose equivalent from all sources, excluding natural background and medical procedures (40 CFR 61.97) (EPA 1982).

Because the radionuclide emission limit is given in the form of a population dose limit, a specific emission limit cannot be derived for each constituent of a radioactive material that contains more than one radioisotope. Instead, performance and risk assessments must be conducted to determine whether current or future emissions of the constituents present at the site in question will result in a total effective dose equivalent that exceeds the regulatory limits.

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Table 7-2. Potential Applicable or Relevant and Appropriate Requirements for Selected Radionuclides in the 1100 Area Operable Unit. (Sheet 2 of 3)

[d]10 CFR 20 (NRC 1979)--Concentrations in Air and Water Above Natural Background. The U.S. Nuclear Regulatory Commission (NRC) regulations in 10 CFR 20 (NRC 1979) establish radiation protection standards for activities licensed by the NRC. The use of radioactive material not licensed by the NRC is not subject to these regulations; however, these regulations provide the only specific regulatory specification of emission limits for all radionuclides.

The regulations in 10 CFR 20.106 (NRC 1979) state that a licensee shall not possess, use, or transfer licensed material so as to release to an unrestricted area radioactive material in concentrations that exceed the limits in Appendix B, Table II of 10 CFR 20 NRC (1979). The limits apply at the boundary of the restricted area.

Concentrations in Air and Water Above Natural Background for Selected Radioisotopes (μCi/mL)

Radioisotope		Air	Water
^{241}Am	Soluble	2.0×10^{-13}	4.0×10^{-6}
	Insoluble	4.0×10^{-12}	3.0×10^{-5}
^{137}Cs	Soluble	2.0×10^{-9}	2.0×10^{-5}
	Insoluble	5.0×10^{-10}	4.0×10^{-5}

For mixtures of radionuclides in which the identities and concentrations of all constituents are known, the concentration must be limited so that the sum of the ratios of each concentration to its corresponding limit does not exceed unity. If either the identity or concentration of any radionuclide in the mixture is not known, the limiting values are 2.0×10^{-14} μCi/mL for air and 3.0×10^{-8} μCi/mL for water. Other rules are provided for cases in which some, but not all, of the constituent identities and concentrations are known. (Concentration limits are also specified for restricted areas to control occupational doses.)

[e]Environmental Radiation Protection Standards for Radioactive Waste Management and Disposal. The EPA regulations in 40 CFR 191 (EPA 1985b) contain environmental radiation protection standards for the management and disposal of spent nuclear fuel and high-level and transuranic radioactive waste. The regulations require that during waste management, storage, and disposal the combined annual dose equivalent to any member of the public shall not exceed 25 mrem to the whole body and 75 mrem to any critical organ for facilities operated by the DOE and not regulated by the NRC (40 CFR 191.04 and 191.15 [EPA 1985b]). During the disposal period, all potential exposure pathways associated with undisturbed operation of the disposal system shall be considered, including the assumption that individuals consume 2 L/d of drinking water from any significant source of groundwater outside of the controlled area (40 CFR 191.15 [EPA 1985b]). During waste management and storage, the EPA may issue alternative standards if such standards will prevent any member of the public from receiving a continuous exposure of more than 100 mrem/yr dose equivalent and an infrequent exposure of more than 500 mrem/yr from all sources, excluding natural background and medical procedures (40 CFR 191.04 [EPA 1985b])

The 25-mrem annual dose limit (all pathways) is repeated in the EPA regulations in 40 CFR 193 (EPA 1988b), which contain environmental standards for the management, storage, and land disposal of low-level radioactive waste. The regulations in EPA (1983), which contain health and environmental protection standards for uranium and thorium mill tailings, require that remedial actions at inactive uranium processing sites provide reasonable assurance that releases of ^{222}Rn from residual radioactive material to the atmosphere will not:

- Exceed an average (over a year period) release rate of 20 pCi/m^2-s
- Increase the annual average concentration of ^{222}Rn in air at or above any location outside the disposal site by more than ½ pCi/L [40 CFR 192.02(b)] (EPA 1983).

As discussed under the radioactive air standards, the dose limit does not prescribe specific radionuclide concentration limits, and it is thus difficult to use it in setting cleanup standards for individual constituents

The disposal standards in (EPA (1985b) require that, in addition to the dose limits described above, the cumulative releases of radionuclides to the accessible environment for 10,000 yr after disposal shall have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table I (Appendix A to 40 CFR 191) (EPA 1985b) and a likelihood of less than one chance in 1,000 of exceeding 10 times those quantities (EPA 1983). The limits in Table I are given per unit of waste, which may be a specified amount of spent nuclear fuel, high-level waste, or any of the following:

- Each 100 million Ci of gamma- or beta-emitting radionuclides with half-lives greater than 20 yr but less than 100 yr
- Each 1 million Ci of other radionuclides (i.e., gamma or beta emitters with half-lives greater than 100 yr or alpha emitters with half-lives greater than 20 yr
- An amount of transuranic wastes containing 1 million Ci of alpha-emitting transuranic radionuclides with half-lives greater than 20 yr.

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Table 7-2. Potential Applicable or Relevant and Appropriate Requirements for Selected Radionuclides in the 1100 Area Operable Unit. (Sheet 3 of 3)

Release limits are given for a number of radionuclides. The limits for ^{241}Am and ^{137}Cs are 100 and 1,000 Ci per unit of waste, respectively. Caution should be exercised in using these values, however. The specification of limits on both total dose and radionuclide emissions has been a source of confusion, since it is not clear that complying with the latter requirement results in complying with the former. The (EPA 1985b) regulations have been invalidated by the courts and remanded back to the EPA on groundwater protection issues, and it is possible that, during the revision of the groundwater protection standards, the release limits may be deleted from the regulations.

The groundwater protection standards (EPA 1985b) require that the disposal system not cause the radionuclide concentrations averaged over any year in water withdrawn from any portion of a special source of groundwater to exceed the following limits:

- 5 pCi/L of ^{226}Ra and ^{228}Ra
- 15 pCi/L of alpha-emitting radionuclides (including ^{226}Ra and ^{228}Ra but excluding radon)
- The combined concentrations of radionuclides that emit either beta or gamma radiation that would produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr if an individual consumed 2 L/d of drinking water from such a source of groundwater [40 CFR 191.16(a)] (EPA 1985B).

These standards were vacated and remanded back to EPA for further review. The court ruled that the EPA had not adequately explained or reconciled the difference between the 25-mrem/yr individual dose limit for all pathways and the 4-mrem/yr limit for the drinking water pathway that forms the basis for the MCLs under the Safe Drinking Water Act.

[f]Under Subpart H of 40 CFR 61 (EPA 1982) (Clean Air Act regulations), air emissions of radionuclides from DOE facilities shall not exceed those amounts that cause a dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to the critical organ of any member of the public.

[g]This is a State maximum contaminant level. Both WAC 248-54-175 (Ecology 1983) and 40 CFR 141 16 (EPA 1986a) set forth a standard for gross beta particle radioactivity as follows: the average annual concentration of beta particle radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr. The concentration of less than 50 pCi/L is the average annual concentration assumed to produce an annual total body or internal organ dose of 4 mrem.

[h]The standards for both 40 CFR 191 and 40 CFR 193 (EPA 1985b and 1988b) are for all potential exposure pathways

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The lists provided in Tables 7-1 and 7-2 are an initial identification of the proposed ARARs and TBCs that may apply to the contaminants potentially present within the 1100-EM-1 operable unit. The specific applicability of these proposed ARARs and TBCs to the 1100-EM-1 operable unit must still be investigated. However, these lists can be used for screening of remedial alternatives and will provide a basis from which to determine final ARARs.

7.1.2 Development of Standards Where No Applicable or Relevant and Appropriate Requirements Exist

When specific numerical standards, as obtained from ARARs or pertinent TBCs, are not available for the chemicals of interest, it is necessary to develop additional chemical-specific standards to be used in evaluating remedial technology options and selecting cleanup objectives. Both the ARARs and these additional standards are then used to develop numerical performance goals for remedial alternatives.

The development of standards in the absence of ARARs is described as part of RCRA guidance for alternate concentration limits for groundwater protection. Alternate standards or criteria are applied when the maximum contaminant level or health-based standard is not appropriate for the specific conditions of a site. These standards or criteria provide flexibility in cleanup actions by taking into account the specific factors of each site. The same chemical, for instance, may have different target levels for cleanup at different sites, depending on site location and the characteristics of both the waste and the site.

Where ARARs do not exist, the EPA has allowed some flexibility in the application of alternative standards. For example, where the aquifer of concern may be used for drinking water, the cleanup limit could be set on the basis of what would be safe to drink. Alternatively, the limit could be set based on access to the groundwater source and the potential of exposure to populations. If consumption of the groundwater could be restricted by the use of institutional controls, or if the aquifer were clearly unsuitable for use as drinking water, the cleanup limit could be set without regard to drinking water considerations or at a level that takes into account controls at the point of use.

The development of numerical standards in the absence of ARARs is based on an assessment of the health risks presented by the chemicals at a site. Cleanup levels identified through this method must account for risks posed by both carcinogens and noncarcinogens. An allowable health or environmental exposure level must be determined for each constituent. The appropriate level will be dependent on the most vulnerable human or environmental receptor near the facility.

For carcinogenic effects, ambient chemical concentration levels should be selected consistent with a risk range of 1×10^{-4} to 1×10^{-7}. However, in practice the health-based standards are usually set using a target carcinogenic risk of 1×10^{-6}. For noncarcinogenic effects, a hazard index is developed to identify the contaminants of most concern. At sites where both potential carcinogens and noncarcinogens are involved, the potential carcinogens will generally drive the design process; however, during the detailed analysis of alternatives, designs must be reevaluated to ensure that noncarcinogenic risk is reduced to acceptable levels.

The EPA guidance documents do not contain specific instructions on developing standards for radionuclides. In general, a dose limit of 25 mrem/yr (all pathways) has been set in EPA and U.S. Nuclear Regulatory Commission (NRC) regulations for nuclear power operations and waste disposal [e.g., 40 CFR 191 (EPA 1985b), 40 CFR 193 (EPA 1988b)].

If more than one carcinogen exists at a site and/or more than one route of exposure is possible, the carcinogenic exposure must be apportioned among the multiple carcinogens and exposure routes to develop target concentrations for each chemical. One method of apportionment is to divide a target carcinogenic risk level by the number of potential carcinogens, while another is to let one or two "bad actor" chemicals drive the design process. The specific apportionment strategy must be determined on a site-by-site basis. The risk must also be apportioned among routes of exposure if exposure to a chemical for a population occurs by more than one route.

The purpose of considering standards for cleanup, whether mandated through ARARs or developed by using alternative criteria where ARARs do not exist, is to ensure that the technology selected for remediating a site will provide the appropriate level of health and environmental protection to the public and the surrounding environment. Health-risk-based assessments are required for developing adequate standards for remediation technologies where ARARs do not exist. These standards can then be used to evaluate the effectiveness of remedial alternatives for remedying a waste site. Further information on the risk assessment process is provided in Section 7.1.5.

7.1.3 Remedial Action Objectives

Remedial action objectives consist of medium-specific (i.e., groundwater, soil, surface water, and air) or operable-unit-specific objectives for protecting human health and the environment. These objectives should be specific enough to narrow the range of remedial alternatives to be considered, but should not unduly limit the alternatives. Cleanup standards are one example of remedial action objectives; i.e., one objective may be to meet the maximum contaminant levels of the Safe Drinking Water Act of 1974. Another example is an objective to treat and dispose of wastes onsite to avoid transporting waste offsite.

To develop the objectives, site-specific information is required on the contaminants, media, exposure pathways, and remediation goals for a particular site. This information permits a range of treatment and containment alternatives for that site to be specified. Remedial action objectives for protecting human health and the environment should consider the following:

- The contaminant(s) of concern
- Exposure route(s) and receptor(s)
- An acceptable contaminant level or range of levels for each exposure route.

Remedial action objectives are designed to protect human receptors as well as environmental receptors. While the term "human receptors" is specific, the term "environmental receptors" is broad and includes plants and animals as well as soil, air, and water. Objectives intended to protect human receptors should include a target contaminant level and an exposure route, while those intended to protect environmental receptors should include a target cleanup level and the medium of interest.

In general, the contaminant levels that will result in acceptable exposure to humans are better defined than the target cleanup levels for protecting the environment, which are often site-specific and subject to interpretation as well as negotiation with the appropriate regulating agencies. For example, the maximum contaminant levels under the Safe Drinking Water Act of 1974 are health-based limits that must be met for any water that is used for human consumption, whereas cleanup standards that will be applied to an aquifer that is not currently being used for drinking water and does not have the potential for future use may be subject to site-specific negotiations.

Acceptable exposure levels for protection of human health should be based on known and available risk factors and contaminant-specific ARARs, such as those provided in Section 7.1.1. Contaminant levels in each medium should be compared with the acceptable levels to determine where human health is not being protected. Thus, specific cleanup objectives can be developed.

Realistic cleanup objectives for the 1100-EM-1 operable unit cannot be established until the levels and extent of contamination are determined through the RI process.

7.1.4 Point of Applicability of Applicable or Relevant and Appropriate Requirements

Once the remedial action objectives have been determined and the potential ARARs identified, there must be identification of where compliance with the ARARs will be measured for each location. The points of applicability are boundaries that will be used to assess the effectiveness of the alternative technologies. Because remedial action objectives and cleanup standards are developed for each medium of interest (i.e., groundwater, soil, surface water, and air), specific, discrete points of applicability for the ARARs must be considered. For example, applicability should be considered at the following locations:

- Groundwater, immediately below the edge of the waste zone near the groundwater/unsaturated zone interface
- Soil, at the edge of the waste zone
- Surface soil, at the location of waste treatment.

In addition, the effectiveness of different technologies may need to be evaluated at specific points of compliance with consideration of the technology/environment interface. For example, if incineration is used, one point of applicability may be established for emissions to the environment from a stack. The stack emissions are not subject to the specific cleanup standards for the site that is being remedied; however, these emissions are regulated and must meet a given set of standards and requirements.

Many of the standards associated with environmental protection statutes and regulations, such as the Clean Air Act and Clean Water Act (1977), generally apply at the end of the stack or pipe. However, RCRA (1976), CERCLA (1980), and their implementing regulations do not clearly define the point of applicability for testing compliance.

The CERCLA (1980) and its implementing regulations [40 CFR 300 and 40 CFR 302 (EPA 1985f, 1985a, respectively)] do not provide guidance as to whether groundwater cleanup levels must be met throughout a site or must be met only at the site boundary. In addition, neither CERCLA (1980) nor SARA (1986) defines "site boundary." The SARA (1986) states that the boundary of the facility will be defined at the conclusion of the RI/FS. Facility, as used in the definition, refers to the operable waste unit.

The RCRA (1976) and its implementing regulations [40 CFR 264 and 40 CFR 265 (EPA 1980b and 1980a, respectively)] state that the point of compliance for applying the groundwater protection standard and conducting monitoring is specified by EPA. According to 40 CFR 264 (EPA 1980b), the point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the site. The RCRA regulations [40 CFR 264.95 (EPA 1980b)] define the waste management area as "the limit projected in the horizontal plane of the area on which waste is placed." This means the area occupied by the waste and any area contaminated by subsequent waste migration. If the operable unit contains more than one site, the waste management area is described by an imaginary line circumscribing the sites. Thus, the applicable standard or criterion must be met at the boundary of the "waste management area."

Because the source of contamination (the waste site) can be identified through sampling efforts, the points of applicability for compliance testing can be defined. However, contaminated-soil standards are not clearly defined in the regulations; thus, they will be subject to negotiation with the regulating agencies. While standards for groundwater protection are readily available in the regulations and guidance, the point of applicability for compliance testing of groundwater cleanup is much more difficult to define because it must be based on the hydrogeologic conditions at a particular waste site. Until the hydrogeology of a particular waste site is understood, the point at which the cleanup standards are applicable cannot be readily determined.

The EPA has published proposed guidelines that must be considered in determining standards and points of applicability for groundwater cleanup and compliance testing. The guidelines establish a procedure for classifying groundwater within a prescribed area around a facility or activity based on the value, use, and vulnerability to contamination of the groundwater. The three classifications of groundwater, which may afford different levels of protection, are described as follows:

- Class I--Special groundwaters (unusually high value)
- Class II--Current and potential sources of drinking water and water having other beneficial uses
- Class III--Groundwater that is not a potential source of drinking water and is of limited potential use.

The proposed guidelines will establish a procedure for classifying groundwater site by site, rather than by region or aquifer. For a facility or activity that may affect the underlying groundwater, a "classification review area" would be established for the area within a 2-mi radius of the facility or activity. The area could be expanded or reduced on the basis of the prevailing hydrogeological conditions.

The EPA's groundwater-classification system may become a factor in determining the level of protection or remediation for CERCLA and RCRA sites. Because the EPA has estimated that 83 percent to 94 percent of classification determinations will result in Class II designations (current and potential sources of drinking water), drinking water standards may be assumed to apply to the 1100-EM-1 operable unit.

In addition, EPA and NRC have established regulations that are not as restrictive as the RCRA regulations. The regulations in 40 CFR 191 (EPA 1985b) and in 10 CFR 61 (NRC 1988) permit a horizontal and vertical "buffer zone" between a contaminant source and the compliance point. This concept should be examined and its relevance to remediation activities determined as contrasted with the more restrictive EPA requirements.

7.1.5 Risk Assessments and Sensitivity Analyses

Risk assessments and sensitivity analyses are necessary data evaluation tools used throughout the RI/FS process. In the scoping and site characterization phases, risk assessments and sensitivity analyses provide an analytical basis for prioritizing data needs and preliminary assessments of the need for RAs. During the feasibility study phase, risk assessments and sensitivity analyses provide a basis for screening and ranking remedial alternatives.

The scope of a risk assessment is discussed in the Draft Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988a). Analysis of the no-action alternative is described as a baseline risk assessment in Section 3.4.2 of that document (EPA 1988a, p. 3-35 to 3-43). Application of risk assessments during screening of alternatives is discussed in Section 5.2.2.1 of the document (EPA 1988a, p. 5-10). Detailed guidance for the conduct of individual aspects of a risk assessment is provided in the Superfund Public Health Evaluation Manual (EPA 1986b) and the Superfund Exposure Assessment Manual (EPA 1988c).

7.1.5.1 Computer Models. Computer models will be used to assess the relative effectiveness of each remedial alternative with respect to pertinent ARARs, TBCs, and cleanup goals defined through risk assessment procedures (performance objectives). A list of available models and a comparison of the relative merits of each model are provided in Appendix E. More comprehensive lists of available codes for each pathway are provided in EPA (1988c). The plans for development of specialized computer codes for Hanford Site applications are provided in Davis (1988). Two types of models will be evaluated during the analysis of the no-action alternative. For the purposes of this work plan, the two types of models will be categorized as integrated or specialized.

Integrated models are capable of representing all or most of the credible pathways (i.e., groundwater, direct exposure, biotic, air, and surface water) for potential exposure to disposed organic and inorganic (including radioactive) wastes. The advantages of integrated models are that they are easy and inexpensive to apply, the results can be obtained in a relatively short period of time, and the cost of code maintenance can be reduced (i.e., only one code versus several codes).

As opposed to integrated models, specialized models can typically only represent individual elements of the system to be modeled. In some cases, multiple specialized codes will be required to analyze an individual pathway (e.g., groundwater). The advantages of specialized models include a greater defensibility of results and the ability to obtain a more detailed understanding of transport processes and critical parameters along each pathway (i.e., avoid problems associated with a 'black box' approach).

The lack of sufficient site-specific groundwater and soils data precludes the extensive use of specialized models for the analysis of the no-action alternative (i.e., the quantity and quality of available data determine the level of modeling sophistication that is justified). Thus, the initial analysis of the no-action alternative will examine conservative, simplified representations of the actual system. As site characterization data are obtained, more sophisticated models can be justified for the detailed analysis of alternatives including the no-action alternative.

The approach for a risk assessment will be to start with simple models consistent with the quantity of data available. These simple models will provide conservative estimates of the risk associated with the operable unit. If the conservative estimate indicates that the risk is acceptable in accordance with applicable regulations, then further analysis will not be necessary. Prior to concluding that further analysis is not necessary, an independent peer review of the results will be conducted to confirm those results. However, if the conservative predictions indicate that the risk related to a given remedial action is unacceptable, then more data will have to be collected, and more rigorous models may also be used to reduce the conservatism of the analysis. An alternative to collecting more data and using better models would be to eliminate the remedial alternative from consideration.

7.1.5.1.1 Integrated Models. Three integrated models will be considered during the risk assessments and sensitivity analyses conducted for the 1100-EM-1 operable unit. The three models to be considered include (listed alphabetically): GEMS (GSC 1982), PATHRAE (Rogers and Hung 1987), and RAPS/MEPAS (Whelan et al. 1986, 1987). These models are capable of computing health effects resulting from organic and inorganic (including radioactive) contaminant transport via air, biota, soil, groundwater, or surface water pathways. Use of these models for the analysis of the no-action alternative will provide the opportunity to evaluate the relative merits of each model. An indication of the applicability of the integrated models for the analysis of alternatives will also be obtained.

7.1.5.1.2 Groundwater Pathway Models. The groundwater pathway may require the use of specialized models due to the close proximity of the 1100 Area to Richland water supply wells. The need for specialized models will be assessed through the use of relatively simple models. Several different specialized models for the groundwater pathway are available. Groundwater transport models that will be considered include: VAM2D/SATURN (Huyakorn et al. 1984, 1985, 1987), PORFLO (Kline et al. 1983, unsaturated capabilities currently being incorporated), and MAGNUM/CHAINT (England et al. 1985; Kline et al. 1985). An additional model that will be considered is RITZ (Nofziger and Williams 1988). The RITZ model has been applied by the EPA to model vadose zone transport in oily environments in the past. One or more of these specialized models may be used as a primary model or to confirm the results of simplified models, to provide a defensible set of results.

Models capable of representing multiple fluid phases (and/or densities) may be necessary for risk assessments of the 1100 Area. Multiphase codes are state of the art and thus are at various stages of development. Two codes, SWANFLOW (developed by GeoTrans, Inc.) and MOFAT-2D (developed at Virginia Polytechnic Institute) are being considered. The capabilities of these codes and utility of obtaining a multiphase code for risk assessments of the 1100 Area and future sites will be examined during the analysis of the no-action alternative.

7.1.5.1.3 Soil, Surface Water, Air, and Biotic Pathways. Specialized models to estimate health effects resulting from transport through air, biotic, soil, and surface water pathways are not expected to be necessary for 1100 Area risk assessments. The modules for these pathways in the GEMS (GSC 1982), PATHRAE (Rogers and Hung 1987), and RAPS/MEPAS (Whelan et al. 1986, 1987) integrated models are expected to be sufficient based on current understanding of site conditions.

7.1.5.2 Analysis of Exposure Levels. The potential for human exposure to wastes disposed of in the 1100 Area will be assessed using the computer models described above. A combination of integrated and specialized models is expected to be used. The soil, groundwater, surface water, air, and biotic pathways will be considered to determine potential exposure levels. The analysis will also consider the sensitivity of predicted human exposure to variations in input parameter values. This will provide information on the relative importance of parameters to guide site-characterization activities, as well as the necessary information for comparison of exposure predictions with ARARs and evaluation of health risk.

7.1.5.3 Comparison of Model Predictions with Applicable or Relevant and Appropriate Requirements at Points of Applicability. The ARARs and other appropriate standards will determine the necessary form of the results from the computer models (i.e., contaminant concentrations, cumulative dose, etc.). In this respect, a direct comparison between model predictions and ARARs will be possible once the point of application is determined.

7.1.5.4 Evaluation of Health Risk. Evaluations of health risk for the analysis of remedial alternatives will be obtained with the GEMS (GSC 1982), PATHRAE (Rogers and Hung 1987), or RAPS/MEPAS (Whelan et al. 1986, 1987) integrated computer codes. Health risk will be determined by integrating the risks predicted in the exposure assessment caused by carcinogenic, noncarcinogenic, and environmental factors. The sensitivity analyses will provide an indication of the level of confidence (uncertainty) associated with the predictions.

7.2 DEVELOPMENT OF REMEDIAL ALTERNATIVES (PHASE 1 FS)

The objective of the Phase 1 FS is to develop potential remedies, encompassing a range of appropriate waste management options, that protect human health and the environment. A range of options is developed to provide project decision makers with a choice of several approaches to solving the site problems.

Section 7.1.3 presented a preliminary discussion of RA objectives for the 1100-EM-1 operable unit. Specific objectives will be formulated after the RI begins to generate information on the levels and extent of contamination at the operable unit. Broad objectives will be developed during the first portion of the Phase 1 FS based on a review of available data on environmental conditions and past waste disposal practices within the unit and data from initial Phase 1 RI activities. Once the preliminary remedial action objectives are developed, remedial alternatives are developed through a series of steps, which include identification of potentially appropriate general response actions for each environmental medium of concern, the identification of potentially appropriate remedial technologies within each general response action category, and the identification of a representative process option for each remedial technology. Once representative process options are selected, they are combined to develop remedial alternatives for the operable unit or certain specific waste management units within the operable unit.

Other integral tasks in the remedial alternatives development process include a more specific identification of ARARs and a reevaluation of operable unit characterization and remedial technology performance data needs. In addition, it is necessary to communicate the results of the overall process to staff and management personnel involved not only in the FS, but also in the RI. The Phase 1 FS process, as set forth in draft RI/FS guidance (EPA 1988a) is summarized below. Further details can be found in EPA (1988a) and associated EPA guidance on technology development and screening methodologies.

7.2.1 Development of Remedial Action Objectives

A discussion of the process for developing remedial action objectives for the 1100-EM-1 operable unit was presented in Section 7.1.3. Preliminary broad-scope objectives developed under this task will be medium specific and will consist of goals for protecting human health and the environment. Media initially considered will be soil, groundwater, surface water and sediments, air, and biota. Of these media, soils and groundwater are expected to be of primary concern. Most of the waste management units at the operable unit have been inactive for a number of years and have since been covered with soil. Therefore, air impacts are not anticipated. In addition, no surface water bodies, permanent or ephemeral, are present in the immediate vicinity of the operable unit. Therefore, the need for surface water and sediment remediation is not anticipated.

Data generated during the initial portion of the first phase of the RI will be used in the development of the preliminary RA objectives. The development will involve the identification of specific contaminants of concern, exposure pathways, and acceptable contaminant levels or ranges of levels for each exposure route to the extent that such information is available at the time of Phase 1 FS initiation.

7.2.2 Development of General Response Actions

Preliminary general response actions for the 1100-EM-1 operable unit will be identified during this Phase 1 FS activity. These response actions will be medium specific, and will describe the general activities that satisfy each of the preliminary RA objectives. Since the response actions relate directly to the RA objectives, any substantial changes in the objectives during the FS process, as additional site characterization data is obtained during the RI, will require that the response actions be refined.

Volumes of contaminated soil and groundwater will be defined based on the early results of the RI. Other media, such as air, surface water and sediments, or biota, will be considered if they are determined as being a source of unacceptable risk to human health or the environment.

7.2.3 Identification of Potential Remedial Technologies

The first activity to occur during this step of the FS will be to identify potential remedial technologies that are appropriate to each general response action category identified under Section 7.2.2. Upon identification of potential remedial technologies, technology process options applicable to each will also be identified. Remedial technologies are general categories of waste management technologies within a particular general response action category, whereas process options are specific waste management processes under a particular remedial technology category.

Once potential technologies and options have been developed, a screening step will take place. During this screening step, process options and entire remedial technology types are eliminated from further consideration on the basis of technical implementability. Technical implementability refers to the ability of the technology or process option to meet the general response action with which it is associated, given specific site conditions. At this point, an analysis will not be performed to assess the ability of the technology or process option to meet cleanup goals.

7.2.4 Evaluation of Process Options

This step of the alternatives development process will consider those process options considered to be technically implementable and will attempt to select one process to represent each technology type. This simplifies the subsequent development and evaluation of alternatives without limiting flexibility during the design of the selected remedy.

During this step, the final list of process options will be evaluated in three steps; the steps are concerned with effectiveness, implementability, and cost. The primary focus of this evaluation will be on effectiveness. A representative process will be selected for those groups of process options determined to be similar in terms of effectiveness, implementability, and cost. If two or more processes are sufficiently different in their performance or effect that one would not adequately represent the other, they will all be retained for further consideration.

Some innovative technologies may be applicable at the 1100-EM-1 operable unit. However, it is likely that detailed data on their effectiveness and cost will not be available. Therefore, the evaluation of these technologies will be somewhat more liberal than would be normal. Innovative technologies will be retained based primarily on their implementability. Effectiveness and cost will not be the basis for elimination of innovative technologies from consideration unless there is clear evidence that one of these factors is limiting.

7.2.4.1 Effectiveness Evaluation. The effectiveness evaluation will focus on the following:

- The potential effectiveness of the process options in handling the estimated areas or volumes of contaminated media and meeting the contaminant reduction goals identified in the general response action
- The effectiveness of the process options in protecting human health and the environment during the construction and implementation phase
- How proven and reliable the process is with respect to the contaminants and conditions at the operable unit.

Sufficient information to evaluate the effectiveness of process options for the various environmental media will be collected during the RI. In some cases it may be necessary to conduct limited conceptual feasibility-level designs of treatment processes under consideration, particularly if innovative technologies are involved.

7.2.4.2 Implementability Evaluation. Both technical and institutional implementability are considered as part of this evaluation. Since technical implementability has already been established at this point, the emphasis will be on institutional factors.

Institutional factors include such issues as the ability to obtain necessary permits for any offsite actions; the ability to meet the substantive requirements of relevant permits for onsite actions; the availability of treatment, storage, and disposal services, as appropriate; and the availability of any essential equipment and/or skilled workers.

Institutional factors will also include issues such as relevant DOE orders and environmental requirements. For example, land disposal regulations enforced by EPA and Ecology would be evaluated as an institutional factor with respect to a waste removal and disposal alternative.

7.2.4.3 Cost Evaluation. This will be the least important of the criteria used to evaluate process options at this point in the FS. Relative capital and operations and maintenance costs will be developed to the extent possible and will be largely based on engineering judgement and experience. Processes will be evaluated as to whether costs are high, low, or medium relative to other process options in the same technology type. It is important to note that the cost evaluation performed here is focused on process options within a given remedial technology only. It is used only for the purpose of selecting the best process option to represent the remedial technology category under consideration. Under no circumstances will cost be used to eliminate any remedial technology category from consideration at this point in the process.

7.2.5 Assembly of Remedial Alternatives

Preliminary remedial alternatives will be developed by assembling general response actions for each contaminated environmental medium determined to be of concern. This step of the FS will involve redefining these general alternatives based on the results of the activities discussed above. This will mainly involve specifying the process options that comprise each alternative.

Alternatives will be assembled so as to present a range of waste management options for further evaluation and ultimate selection by project decision-makers. To ensure such a range, the following types of alternatives at a minimum should be developed, if practicable:

- An alternative emphasizing no further action

- An alternative emphasizing institutional controls
- An alternative emphasizing waste removal and onsite disposal
- An alternative emphasizing waste removal and offsite disposal
- An alternative emphasizing waste containment
- An alternative emphasizing waste treatment resulting in the permanent reduction in the volume, mobility, or toxicity of waste.

Because there is a statutory preference for permanent waste treatment, it is appropriate to develop various treatment alternatives, emphasizing different treatment technologies and degrees of treatment.

The alternatives will be assembled in such a manner as to address either the entire operable unit or specific individual waste management units within the operable unit. The latter approach is more likely, because of the distinct nature, in terms of both location and operational history, of the various waste units covered under this particular project.

7.2.6 Identification of Applicable or Relevant and Appropriate Requirements

Once remedial alternatives have been assembled during this phase of the FS, potential contaminant-, location-, and action-specific ARARs, pertaining to operable unit conditions and the technologies selected, will be identified or refined from those preliminarily presented in Section 7.1. These requirements, as mentioned earlier, will provide feasibility-level design goals for the next phase of the FS.

Because identification of ARARs is an ongoing process in itself, a verification step, involving active participation on the part of the environmental regulatory agencies, is included under the Phase 2 FS.

7.2.7 Reevaluation of Data Needs

In the process of performing the Phase 1 FS, additional data needs may be determined. The FS coordinator will communicate these needs to the RI coordinator so that the Phase 1 RI can be modified, if necessary. Additional data, including results of any required treatability testing, will be obtained during the Phase 2 RI, as described in Appendix F. The interim Phase 1 FS report will serve as a means of documenting the data needs identified under this task.

7.2.8 Interim Phase 1 Feasibility Study Report--Remedial Alternatives Development Summary

An interim Phase 1 FS report will be prepared upon completion of the tasks described above. The following types of information will be included:

- Summary of background information supplemented with available scoping information and any initial RI data, including the nature and extent of contamination and contaminant fate and transport
- Identification of the preliminary remedial action objectives and general response actions for each environmental medium of concern
- Identification and screening of remedial technologies and process options
- Selection of representative process options
- Incorporation of selected process options into a range of remedial alternatives.

The report will also serve as a means of identifying and communicating any reevaluations of data needs for the RI. It is particularly important that all assumptions made and rationale used during alternatives development, especially with respect to any screening performed, be documented.

This report is viewed as an interim informal deliverable. It will be incorporated into the formal Phase 1/2 FS report.

7.3 SCREENING OF REMEDIAL ALTERNATIVES (PHASE 2 FS)

The screening of alternatives follows the development of, and precedes the detailed analysis of, alternatives. The objective of alternative screening is to reduce the list of potential remedies that will be evaluated in detail, based on their relative effectiveness, implementability, and cost. This screening ensures that the most promising potential remedies are being considered and narrows the scope of the Phase 3 FS to manageable proportions. To the extent practicable, a range of appropriate waste management options, as discussed in Section 7.2.5, will be preserved so as to allow project decision-makers significant choices for an operable unit remedy.

Three distinct steps are conducted during the screening of remedial alternatives. First, the alternatives selected in Phase 1 are further refined based on the quantities or areas of environmental media affected, the sizes and capacities of process options, and other pertinent factors obtained from the RI. Second, the refined alternatives are evaluated on a general basis to determine their effectiveness, implementability, and cost. Third, the alternatives best able to meet the remediation objectives of protection of human health and the environment are retained for detailed analysis in Phase 3 of the FS.

The following is a brief summary of the Phase 2 FS process. Further details can be found in EPA (1988a).

7.3.1 Refinement of Remedial Action Objectives

Alternatives are developed in Phase 1 of the FS to meet remedial action objectives for each environmental medium of interest. However, exposures may occur through more than one pathway and involve several environmental media. The assembled alternatives are thus evaluated to ensure that they protect human health and the environment from all potential pathways at the operable unit. If it is found that an alternative is not fully protective, a reduction in exposure levels may need to be made for one or more media, or it may be determined that a specific alternative is unable to meet a target risk level and would, therefore, not be retained. Conversely, it may be determined that certain media do not pose an unacceptable risk, and treatment alternatives possibly could be eliminated from further evaluation.

Information obtained in the RI will be used to refine the objectives to consider media interactions so that alternatives are fully protective of public health and the environment.

7.3.2 Definition of Remedial Alternatives

Prior to beginning the screening, alternatives must be further defined to identify individual process options, process sizing requirements, and remediation time frames. Results from the RI will be used to determine interactions among environmental media that may influence remediation activities. Alternatives will be redefined, as necessary, to provide for protectiveness for the entire operable unit.

The information collected during the RI will be used to refine the extent or volume of contaminated material and the size of major technology and process options to allow differentiation among alternatives with respect to effectiveness, implementability, and cost.

Media interactions will be evaluated to determine if ongoing releases (such as from contaminated soils) significantly affect contaminant levels in other media (such as groundwater). This is necessary because source control actions affect remediation levels and time frames for other media. For example, source removal of contaminated soils would reduce the rates and volumes of groundwater extraction needed to achieve the target remediation levels.

After the alternatives have been defined, the technology process options will be further defined with respect to effectiveness, implementability, and costs to identify differences among alternatives. The following information will be developed for the technology process options used in an alternative:

- Size and configuration of onsite extraction and treatment systems
- Time frame in which treatment, containment, or removal goals can be achieved
- Rates or flows of treatment
- Special requirements for construction
- Distances for disposal technologies
- Required permits and imposed limitations.

7.3.3 Screening Evaluation

In the screening evaluation, information assembled in the further definition of alternatives is used to evaluate the alternatives with regard to the short- and long-term aspects of effectiveness, implementability, and cost. During this screening, comparisons will be made between similar alternatives, with the most promising carried forward for further analysis.

Alternatives with the most favorable composite evaluation of all factors will be retained for further consideration during the detailed analysis. To the extent practicable, alternatives selected will preserve the range of treatment and containment technologies initially developed. Unselected alternatives may be reconsidered at a later step in the detailed analysis if information is developed that identifies an additional advantage not previously apparent. However, it is expected that alternatives eliminated during this phase will not be reconsidered for selection.

7.3.3.1 Effectiveness Evaluation. Each alternative will be evaluated with respect to the level of protectiveness to human health and the environment that it will provide through reductions of waste in terms of toxicity, mobility, or volume. The short-term component, occurring during the construction and operation period, and the long-term component, occurring after the remedial action alternative has been completed, will be evaluated. Levels obtained in reduction of toxicity, mobility, or volume will be compared to contaminant-specific ARARs, pertinent TBCs, or target risk levels.

7.3.3.2 Implementability Evaluation. Implementability is a measure of both the technical and institutional feasibility of constructing, operating, and maintaining a remedial alternative with respect to a specific site. Technical feasibility refers to the ability to construct, operate, and meet technology-specific regulations for process options. Institutional feasibility refers to the ability to obtain approvals and any necessary permits from Federal, State, and local agencies and to procure required services and equipment.

7.3.3.3 Cost Evaluation. Comparative cost estimates will be based on cost curves, generic unit costs, vendor information, conventional cost-estimating guides, and prior similar estimates. Both capital and operating and maintenance costs will be considered where appropriate. Present worth analyses will be used to evaluate expenditures that occur over different time periods, so that costs for different remedial alternatives can be compared on the basis of a single figure for each alternative.

Costs will only be used to screen alternatives within a given alternative category. For example, any form of treatment, containment, or removal and disposal alternative is likely to be more costly than one emphasizing no action. It is inappropriate to screen the active alternative in favor of the no-action alternative on the basis of cost. However, if two treatment alternatives, for example, are substantially similar in terms of effectiveness and implementability with one's having a cost that is significantly higher than the other, it may be appropriate to eliminate the higher cost treatment alternative from further consideration. In short, cost alone is not an acceptable justification for reducing the range of appropriate waste management options under consideration.

7.3.3.4 Evaluation of Innovative Alternatives. Innovative technologies are those technologies that are fully developed but lack sufficient cost or performance data for routine use at hazardous waste sites. Therefore, it will most likely not be possible to evaluate alternatives incorporating innovative technologies on the same basis as available technologies. However, innovative technologies will be carried through the screening phase if there is reason to believe that they offer significant advantages.

7.3.4 Verification of Applicable or Relevant and Appropriate Requirements

At the conclusion of screening, sufficient information will exist on the technologies and configurations of greatest interest to perform a more definitive identification of ARARs. The ARARs previously identified will be refined with input from the Federal and State environmental regulatory agencies. Regulatory agency participation will be important in providing project focus and direction and in easing the regulatory review of the Phase 1/2 FS report.

7.3.5 Reevaluation of Data Needs

Once the field of alternatives has been narrowed, the need for any treatability testing will be apparent. Such testing will occur during the Phase 2 RI. Additional site characterization data needs may also be identified during the alternatives screening phase. However, it is expected that the nature and extent of contamination will be well defined by the end of the RI. Therefore, any additional field investigations deemed to be needed during the Phase 2 RI will focus on better defining the effect of operable unit conditions on the performance of the technology processes of greatest interest. Data quality objectives will be refined or developed, as necessary, for any additional investigations.

7.3.6 Phase 1/2 Feasibility Study Report--Remedial Alternatives Development and Screening Summary

The results of the initial screening of alternatives will be combined with the interim Phase 1 FS to develop a document summarizing both the development and screening of alternatives for the 1100-EM-1 operable unit. The procedures for developing, evaluating, defining, and screening the alternatives will be well documented. The following types of information will also be included:

- Definition of each alternative including extent of remediation, volume of contaminated material, sizes of major treatment processes, process parameters, cleanup time frames, transportation distances, and special considerations
- Notation of process options that were initially screened out and are being represented by the processes comprising the alternative
- Screening evaluation summaries of each alternative.

A reevaluation of data needs for the Phase 2 RI will be included in this report. Details of this report will, in turn, be summarized in the final FS report for the project, which is to be prepared under the third phase of the FS.

7.4 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES (PHASE 3 FS)

The detailed analysis of alternatives follows the development and screening of alternatives and precedes the actual selection of the remedy to be implemented at the operable unit. The results of the detailed analysis provide the basis for identifying a preferred alternative and preparing the proposed operable unit remedial action plan. The detailed analysis of alternatives consists of the following components:

- Further definition of each alternative, if appropriate, with respect to the volumes or areas of contaminated environmental media to be addressed, the technologies to be used, and any performance requirements associated with those technologies

- An assessment and a summary of each alternative against nine evaluation criteria

- A comparative analysis among each of the alternatives that will facilitate the selection of an operable unit remedy.

The results of this phase, along with a summary of the first two phases, are then documented in a final FS report.

The brief summary of the Phase 3 FS process presented below was derived from EPA (1988a).

7.4.1 Definition of Remedial Alternatives

The alternatives that remain after screening may need to be defined more completely before the detailed analysis is begun. During the detailed analysis, each alternative will be reviewed to determine if additional definition is required to apply the evaluation criteria consistently and to develop order-of-magnitude cost estimates (-30 to +50 percent). Information developed to further define alternatives at this stage may include preliminary design calculations, process flow diagrams, sizing of key process components, preliminary site layouts, and a discussion of limitations, assumptions, and uncertainties concerning each alternative. Information collected from treatability investigations, if conducted, will also be used to further define alternatives.

7.4.2 Detailed Analysis of Remedial Alternatives

Nine evaluation criteria will serve as the basis for conducting the detailed analysis and for subsequent selection of a cost-effective and protective remedy:

- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost
- Compliance with ARARs
- Overall protection of human health and the environment
- Environmental agency acceptance
- Community acceptance.

These criteria encompass technical, cost, and institutional considerations, compliance with specific statutory requirements, and community relations concerns.

7.4.2.1 Short-Term Effectiveness Analysis. This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until remedial action objectives are met. The following factors relating to effects on human health and the environment will be addressed for each alternative:

- Protection of the community during construction and implementation
- Protection of workers during construction and implementation
- Environmental impacts during construction and implementation
- Time until remedial action objectives are achieved.

The evaluation of these factors will include a discussion of increased risk posed by the remedial alternative being evaluated and an evaluation of the effectiveness and reliability of protective measures that could be taken for worker protection or environmental impact mitigation.

7.4.2.2 Long-Term Effectiveness Analysis. The evaluation of alternatives using this criterion will address the results of a potential remedy in terms of the risk that would remain at the operable unit after remedial action objectives have been met. The following components will be addressed to evaluate the extent and effectiveness of controls that may be required to treat residuals or untreated wastes:

- Magnitude of remaining risk
- Adequacy of controls
- Reliability of controls.

The evaluation of these components will include an assessment of residual risk, the adequacy of containment systems and institutional controls, and the potential need to replace components of the remedial alternative.

7.4.2.3 Analysis of Reduction in Waste Toxicity, Mobility, and Volume. This evaluation criterion addresses the statutory preference for selecting remedies that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of a hazardous substance as their principal element [CERCLA 121 (b)(1), 1980]. The following specific factors will be addressed:

- The treatment processes, the remedies they will employ, and the materials they will treat
- The amount of hazardous materials that will be destroyed or treated
- The degree of expected reduction in toxicity, mobility, or volume as a percentage of reduction
- The degree to which treatment will be irreversible
- The type and quantity of treatment residuals that will remain.

Alternatives that treat a site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volumes of contaminated media will be deemed to satisfy the preference for permanent treatment.

7.4.2.4 Implementability Analysis. Implementability refers to the technical and institutional feasibility of implementing an alternative and the availability of various services and materials required during its implementation. In evaluating this criterion, the following factors will be analyzed:

- Technical feasibility including construction and operation, reliability of technology, ease of undertaking additional remedial actions, and monitoring considerations
- Institutional feasibility
- Availability of services and materials.

7.4.2.5 Cost Analysis. Cost considerations will be an important evaluation criterion at the Hanford Site because funding is distributed by the U.S. Congress. Costing procedures outlined in the Remedial Action Costing Procedures Manual (EPA 1987g) will be used in the alternatives evaluation.

Both capital costs and annual operation and maintenance costs will be considered. Cost will be developed within an accuracy of -30 to +50 percent. In addition, a present worth analysis will be conducted so that all alternatives can be compared on the basis of a single figure in a common base year. A discount rate of 5 percent will be used along with a period of performance of 30 yr.

7.4.2.6 Analysis of Compliance with Applicable or Relevant and Appropriate Requirements. This evaluation criterion is used to determine how each alternative complies with ARARs. The detailed analysis will summarize which Federal and State environmental standards, requirements, criteria, or limitations are applicable or relevant and appropriate to an alternative. How the alternative meets these requirements will be described.

7.4.2.7 Analysis of Overall Protection of Public Health and the Environment. This evaluation criterion provides a final check to assess whether each alternative meets the requirement that it be protective of human health and the environment. The overall assessment of protection is based on a composite of factors discussed under long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. The analysis will address how each specific alternative achieves protection over time and how operable unit risks are reduced. A discussion will be included of how each source of contamination is to be eliminated, reduced, or controlled for each alternative.

7.4.2.8 Analysis of Environmental Agency Acceptance. Because the EPA and Ecology will have an opportunity to review and comment on the FS report, this analysis will be limited to formal comments made by the agencies during previous phases of the RI/FS. Agency comments on the remedial alternatives analysis phase will be specifically addressed in a responsiveness summary prior to finalization of an ROD that documents the selection of the remedy.

Therefore, the analysis of this criterion will focus on those features of alternatives that the EPA or Ecology have reservations about or oppose. A brief discussion of what processes were used to incorporate environmental agency inputs to the project will be included.

7.4.2.9 Analysis of Community Acceptance. The potentially affected community, special interest groups, general public, and other interested governmental agencies will have an opportunity to review and comment on the FS report as well. Before the ROD is developed, community concerns will also be addressed in the responsiveness summary. Thus this analysis will also be confined to community concerns formally transmitted to project management personnel earlier in the RI/FS.

7.4.3 Comparison of Remedial Alternatives

Once the alternatives have been individually assessed against the nine criteria described above, a comparative analysis will be conducted to evaluate the relative performance of each alternative in relation to each specific evaluation criterion. The key tradeoffs or concerns among alternatives will generally be based on the evaluations of short-term effectiveness; long-term effectiveness and permanence; reduction of toxicity, mobility, and volume;

implementability; and cost. Overall protectiveness and compliance with ARARs will generally serve as a threshold determination in that they either will or will not be met.

The comparative analysis will include a narrative discussion describing the strengths and weaknesses of the alternatives relative to one another with respect to each criterion. The potential advantages in cost or performance of innovative technologies and the degree of uncertainty in their expected performance will also be discussed. The differences between all the alternatives will be summarized in tabular form.

7.4.4 Feasibility Study Report

The analysis of individual alternatives against the nine criteria will be presented as a narrative discussion accompanied by a summary table. The alternatives discussion will include data on technology components, quantity of hazardous materials handled, time required for implementation, process sizing, implementation requirements, and assumptions. The key ARARs for each alternative will also be incorporated into those discussions. The discussion will focus on how, and to what extent, the various factors within each of the nine criteria are addressed. A summary table will highlight the assessment of each alternative with respect to each of the nine criteria.

Based on the results of the comparison of alternatives, the FS report will indicate which remedial alternative is preferred. The preferred alternative will provide the basis for the proposed remedial action plan.

7.4.5 Proposed Remedial Action Plan

In accordance with Section 117 of CERCLA (1980), a brief analysis of the preferred remedial alternative or proposed remedial action plan will be published for public review and comment. The proposed plan and FS report will be made available for public review at the same time, after regulatory approval. The proposed plan will consist of a very brief summary, written for the public in terms of content and distribution, of the nature and extent of contamination at the 1100-EM-1 operable unit, the overall remedial action process, the preferred alternative and its advantages and disadvantages, and the other alternatives that are fully developed and analyzed in the Phase 3 FS.

Significant comments on the proposed plan will be addressed in a responsiveness summary to be prepared during the selection-of-remedy process that immediately follows the RI/FS. The proposed plan will be finalized based on comments, if necessary, and published as a final remedial action plan. The remedy selection process will then be formally documented in an ROD developed between DOE, EPA, and Ecology.

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8.0 DATA MANAGEMENT PLAN

An extensive amount of data will be generated over the next several years in connection with the RI/FS process that will be conducted to evaluate and remediate hazardous waste sites at the Hanford Site. The quality of the data must be beyond reproach because they will be used to evaluate the need, select the method(s), and support the full remediation of the waste sites as agreed upon by the DOE, EPA, Ecology, and interested parties. Thus, a comprehensive plan for the management of this extensive amount of data is absolutely essential.

8.1 INTRODUCTION AND OBJECTIVES

This section describes a two-component data management system (DMS) for accessing and tracking the receipt, storage, and control of validated data, records, documents, correspondence, and other associated information. These components include a computer-based component and an administrative component to handle, store, and protect physical records and samples.

This section outlines the following:

- Types of data and information that are expected to be collected
- Currently available computer-based and administrative components
- Plans for developing any needed interim administrative components
- Plans for developing a comprehensive computer-based component that integrates selected existing and anticipated computer data bases
- Plans for establishing an information repository for maintaining the official paper (hard-copy) records associated with each operable unit.

Procedures for the system will be developed for directing project-authorized personnel as to the manner in which data are received, stored, tracked, amended, and disseminated so that a record of control is always maintained. These procedures will be developed to ensure that the integrity of the data is maintained. The procedures will be provided in a detailed data system procedure manual that describes how data can be entered, accessed, processed, and amended so that a record of use and changes or modifications to the data is maintained. Accessibility of the data base by all interested parties will allow access as described in the Agreement and Action Plan.

The data system procedures manual will include the procedures necessary for handling and tracking the information that must be maintained in the administrative record for each operable unit as well as physical (hard-copy) records associated with each unit. It will also include procedures for operation and control of the computer-based component of the system.

Existing procedures will be used or modified, or new procedures will be developed, to address records management for the following general subject areas:

- Congressional inquires and hearings
- Discovery
- Remedial planning, investigation, and feasibility study
- Remedial design and implementation
- EPA and State agency coordination
- Community relations
- Imagery (photographs, maps, illustrations, etc.)
- Enforcement activities
- Contracts
- Financial records.

An Environmental Information Management Plan (WHC 1989) addresses development of the data management system discussed here and includes as a task the development of the data system procedure manual mentioned above. The plan also identifies general requirements, procedures, and responsibilities for managing environmental data and provides milestone and scheduling information associated with implementing development of the DMS.

The computer-based component is the HEIS, currently being developed by PNL. The HEIS will be used to manage the extensive amount of data that will be collected and generated during the RI/FS and site-remediation processes. The HEIS is a computer-based information system that is designed to receive, store, and provide for access to quality-assured data concerning Hanford Site environmental and regulatory issues. As shown in Figure 8-1, the HEIS is an integrated data base designed to integrate existing operational data bases and provide a dedicated facility for data being gathered as part of the CERCLA process. This allows for accessing and evaluating the data that is collected and generated by the individual Hanford Site environmental data base programs [e.g., Hanford groundwater data base, surface monitoring program data and management system (PDMS), waste information data system (WIDS), Hanford inactive site survey (HISS)], while maintaining the integrity of the individual data bases. Furthermore, implementation of HEIS will serve to ensure that consistency is achieved through incorporation of all data within a single data base.

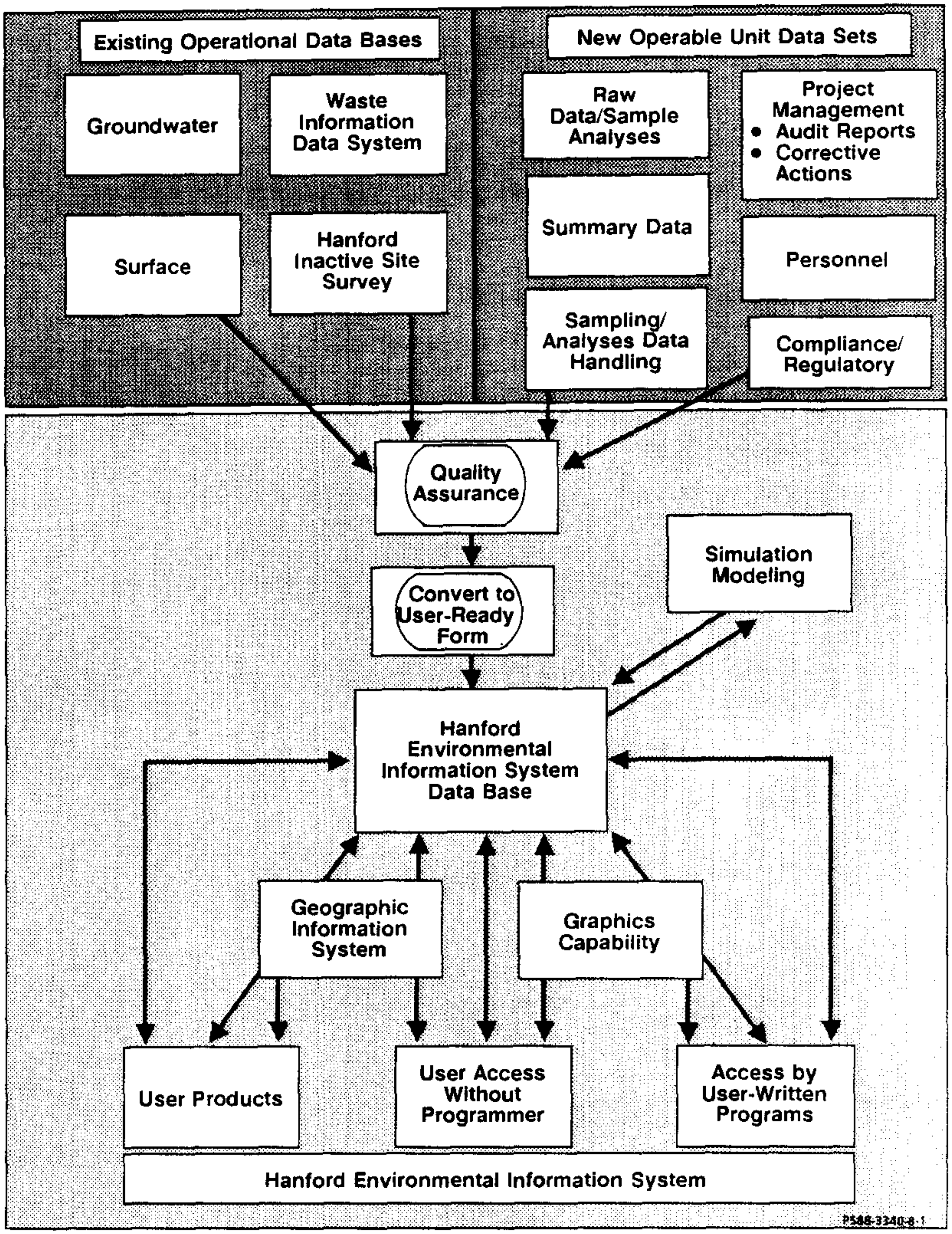

Figure 8-1. Framework of the Hanford Environmental Information System.

The HEIS will provide the following:

- User support capabilities
  - A geographic information system
  - Integrated graphics support
  - Comprehensive user access capabilities
- Access by personal computers via existing networks
- Security of the data bases.

The computer-based component will serve to list and locate paper records and physical samples. The HEIS will maintain much of the various types of raw site (operable unit) data, verified program and summary data, and results of approved analytical computer programs. The results of such analyses will be stored separately from the original data files.

The ability to enter data into raw data files will be restricted to maintain control of validated data. Any actions required to validate or modify data will be procedurally controlled to protect data from being inadvertently or intentionally altered. All changes will be documented and maintained in the system.

The official paper-copy records (administrative record as well as other official paper-copy records) and archived physical samples will be maintained in designated areas that will be specified in the data system procedures manual. The designated areas will be designed such that they will meet all applicable protection and security requirements. Backup record copies will be maintained in accordance with applicable procedures (now under development).

8.2 TYPES OF DATA TO BE COLLECTED AND ANALYZED

Records and types of data to be tracked during the RI/FS process at the Hanford Site are shown in Table 8-1. The "raw data" represents the actual field and laboratory measurements or observations that will be made during the RI/FS processes. The "summary data" represents the first-order analyses of the "raw data." "Program tracking" includes information that is programmatic or administrative in nature. It represents the data that are required for the conduct of a project; however, it does not include the field or laboratory data.

Validated data gathered during RI/FS investigations will be kept separate from other Hanford Site project data by placement in separate files within the data management system. However, many of the ongoing Hanford Site projects will provide data that will undoubtedly be very useful for the Hanford Site RI/FS investigations. Data will be stored such that they may be accessed for analyses, the results of which will be stored separately.

Table 8-1. Types of Remedial Investigation/Feasibility Study Information and Data to be Collected.

Characterization	
Raw data/sample analyses	Groundwater samples Sediment samples Surface water samples Atmospheric samples Personnel exposure monitoring records Geophysical information Biota samples Site descriptive information (topography, geological and ecological features) Pilot/bench test data Engineering design data
Summary data	Analytical results of environmental media by time, location, depth, contaminant, etc. Health risk assessment results Engineering test results Graphic information system outputs
Sampling/analyses/data handling	Sampling schedule Sample collection procedures Field/laboratory notebooks Analyses scheduling Laboratory quality assurance/quality control Calibration tracking Instrument coordination Data entry procedures Data reduction, validation, storage and transfer procedures
Tracking	
Project management	Project schedule and milestones Project costs Equipment, personnel, and supplies scheduling Document tracking Subcontracts Project quality assurance/quality control procedures
Personnel	Personnel training and qualifications Occupational exposure records Personnel health and safety records
Compliance/regulatory	Applicable or relevant and appropriate requirements/ screening levels Guidance document tracking Compliance issues Problem resolution

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A reference collection of applicable EPA, Ecology, DOE, and Hanford Site contractor documents, drawings, and correspondence will be maintained to support site characterization and remedial investigation activities. The ARARs drawn from Federal and State requirements and standards will be kept and updated in a timely manner. Compliance requirements will also be maintained and updated periodically.

8.3 DATA MANAGEMENT PLAN SCOPE RELATIVE TO OTHER REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN COMPONENTS

The DMS will receive and control validated data obtained through implementation of the SAP, HASP, and feasibility study segments of this work plan. The QA plan includes provisions to ensure quality data and results of analyses. The SAP provides the detailed logistical methods to be employed in selecting the location, depth, frequency of collection, etc., of media to be sampled and methods to be employed to obtain samples of the selected media for cataloging, shipment, and analyses. The data that result from the analyses will be entered into the DMS for subsequent control and tracking. In a similar manner, data from field and bench tests of potential remedial techniques is entered into the DMS. Procedural control for such testing is found in the QA plan. Specific directions and logistical methods to be employed for field and bench testing are found in the technology plan. Site and personnel health data needed to ensure worker safety are specified in the HASP, which also specifies the manner in which these data are to be obtained. Personnel health records will be protected as required by the Privacy Act and secured in such a way that only authorized personnel will have access to these data.

8.4 PROCEDURAL CONTROL OF DATA MANAGEMENT SYSTEM

The DMS will be procedurally regulated by the data systems procedure manual to be developed. As specified in the Environmental Information Management Plan (WHC 1989a), an in-process document control procedure and 1100-EM-1 procedure will be utilized in the interim (see also Appendix C). A specific example relating to surface environmental monitoring is given in Figure 8-2.

8.5 IDENTIFICATION OF EXISTING DATA BASE SYSTEMS

Several data bases are currently in use at the Hanford Site. These data bases were developed for a variety of different purposes and uses. However, much of the information and data-handling capabilities associated with these data bases is directly useful to RI/FS evaluation of the various operable units located on the Hanford Site. A listing of the existing data bases that are available is provided in Table 8-2.

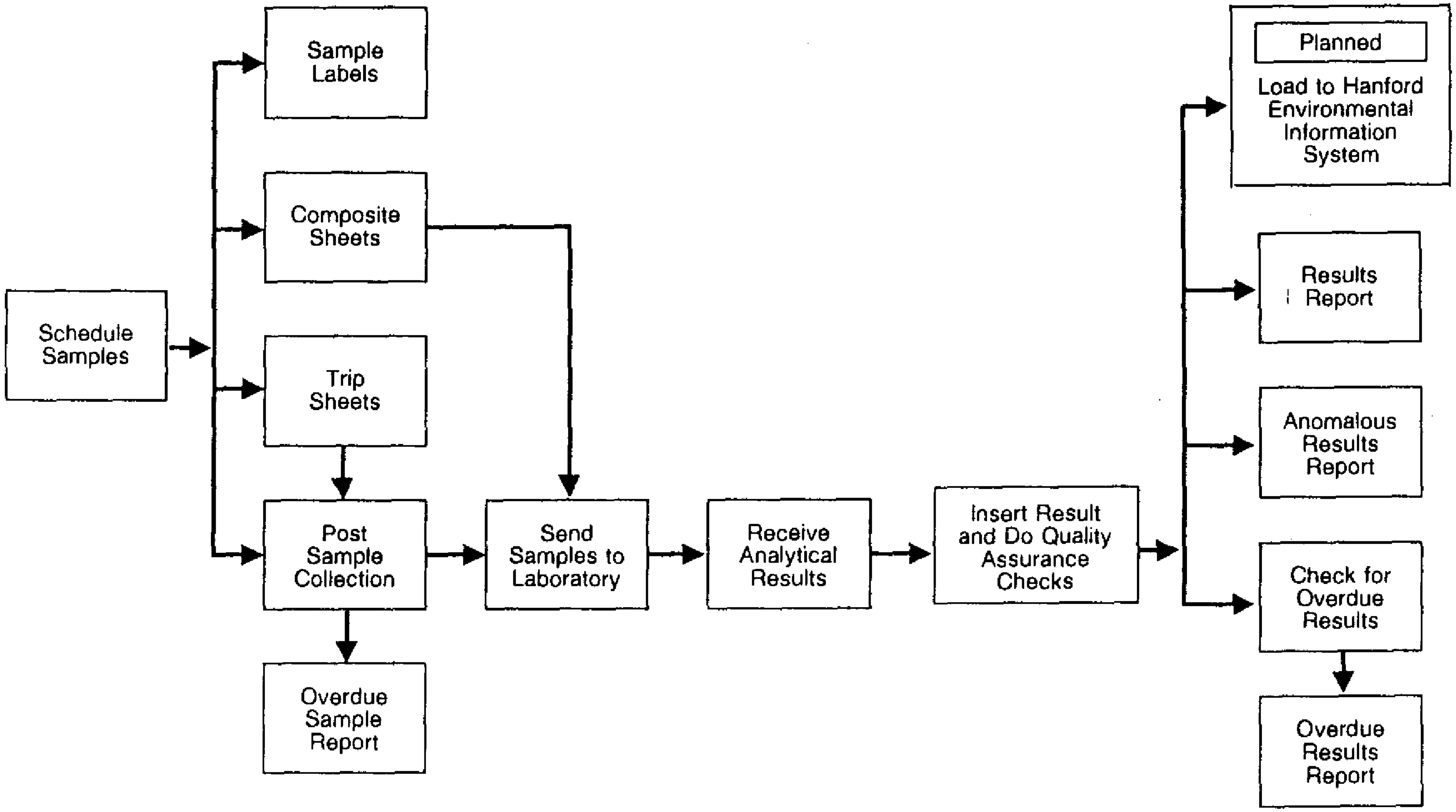

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Figure 8-2. Example Procedure for Collecting, Handling, and Analyzing Samples and for Entry of the Results.

Table 8-2. Existing Hanford Data Bases.

Data base name	Information type
Hanford Groundwater Data Base	Contains chemical and radionuclide analytical results for groundwater and sediment samples
Program Data and Management System (PDMS)	Contains chemical and radionuclide analytical results of air, surface water, soil, vegetation, wildlife, and foodstuffs samples
Waste Information Data System (WIDS)	Contains information on the physical and environmental characteristics of waste units at the Hanford Site (radioactive and hazardous chemicals)
Hanford Inactive Site Survey (HISS)	Contains detailed preliminary assessment/site inspection information on individual waste sites at the Hanford Site
Hanford Environmental Compliance Report (HECR)	Contains information on Hanford Site waste streams for tracking environmental compliance issues
Environmental Compliance Tracking System (ECTS)	Contains regulatory flowsheet information for tracking compliance with Federal, State, and local environmental regulations
Sample Preparation System	Generates labels, reports, etc. for sampling preparation and contains information on facilities, location, and time of sampling and chain-of-custody information
Basalt Waste Isolation Project Technical Data System	Contains information on hydrological conditions and some geological data for the Hanford Site. Also contains site characterization, hydrological data, hydrochemistry, stratigraphy, and constituent data
Warehouse Inventory Management System	Keeps track of all the hazardous material purchased at the Hanford Site
Flow Gemini--Environmental Information System	Will contain information associated with onsite monitoring for exposures to hazardous materials (e.g., monitoring well drilling for gaseous releases)
Flow Gemini--Occupational Health Information System (medical information tracking system)	Contains employee medical information
Material Safety Data Sheet System	Contains information on chemicals found at the Hanford Site. Currently this is a manual system operated by HEHF, but it is in the process of being computerized. This effort is being coordinated with the SARA Title III right-to-know program at the Hanford Site
Occupational Radiation Exposure	Contains personnel respiratory protection fitting, work restriction, and radiation exposure information
Quality Control Blind Standards Data Base	Contains the results on spiked samples, replicate samples, and interlaboratory comparisons
Training Records Information System	Contains records on individual employee training records
Commitment Control System	Tracks correspondence commitments. A network version is available

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Westinghouse Hanford maintains an Environmental Resource Center that contains copies of environmental and pertinent Federal and Washington State regulations, documents that have been prepared and submitted to Ecology and EPA pertaining to the regulations, and correspondence in support of environmental matters. The Environmental Resource Center contains RCRA permit applications and closure plans as well as RI/FS work plans for individual Hanford Site operable units. Other information such as environmental laws, DOE orders, corporate policies, and case histories will also be added. A computer-based indexing system is presently being developed and will allow rapid identification of appropriate documents, copies of which can be obtained from the Environmental Resource Center files. The Environmental Resource Center will contain copies of all correspondence with Ecology and EPA. This will include primary as well as secondary documents.

8.6 EVALUATION OF EXISTING DATA BASE SYSTEMS

In general, the existing data bases in use on the Hanford Site were designed for specific purposes. They are not integrated to cover anticipated RI/FS needs. These existing data bases will provide supplementary, historical data to support the RI/FS process. The scope of each data base identified in Table 8-2 is discussed separately in the following paragraph.

The Hanford groundwater data base is used to generate the annual "Groundwater Monitoring at Hanford" report. It also contains the Hanford Site's RCRA compliance-monitoring program's groundwater monitoring data. In addition, it has been modified to handle vadose zone (sediment) sample data.

The PDMS is generally used by the Hanford Site to generate the annual "Surface Environmental Monitoring at Hanford" report. It is an overall data base for tracking routine and special air, surface-water, soil, vegetation, wildlife, and foodstuff samples from the Hanford Site.

The WIDS and the HISS data bases were set up specifically to handle hazardous waste site information. The WIDS contains data on the general physical and environmental characteristics associated with the waste units located on the Hanford Site. The HISS contains preliminary assessment/site inspection information on inactive sites at the Hanford Site including fairly detailed information on location, date for receiving waste, types and quantities of waste, cleanup actions, and other similar types of information. In addition, the HISS is supported by the PNL hazard ranking system and modified hazard ranking system evaluation data base, which contains the detailed hazard ranking system and modified hazard ranking system scoring information, with input parameter justifications, for individual waste sites at the Hanford Site. The WIDS system serves as the official Hanford Site waste units identification and tracking system.

The Hanford Environmental Compliance Report (HECR) and Environmental Compliance Tracking System (ECTS) are two systems currently used at the Hanford Site to track compliance. The HECR was developed to provide a uniform method for Hanford Site contractors to use in collecting and maintaining regulatory compliance status information on Hanford Site facilities. Data input into HECR centers primarily around compliance with the various State and Federal legislation that may apply to a particular discharge point at the facility. The discharge point is the primary level for which compliance data are entered. However, the term "discharge point" can be defined with a great deal of flexibility, allowing the system to track individual waste sites or operable units with no difficulty. The HECR provides for entry of additional compliance status information for those points needing follow-up action. This is done to allow tracking of compliance actions on a specific point. The ECTS contains regulatory flowsheet information. It is designed to be used in the evaluation of waste streams for compliance with Federal, State, and local environmental regulations. Waste streams are the primary focus of the ECTS; however, waste streams can be defined with some flexibility to allow the system to be used to track individual waste sites or operable units. The HECR and ECTS can be used in the comprehensive DMS to track compliance status of operable units (or individual sites if conditions warrant).

The sample preparation system was set up to generate labels for sample bottles and to track sample status at the analytical laboratories. It can generate reports on samples collected, samples currently at an analytical laboratory, and samples with results overdue from the laboratory.

The Basalt Waste Isolation Project (BWIP) technical data system was being prepared to contain information on hydrological conditions and some geological data at the Hanford Site. The system was intended to handle data obtained from wells in hydrologic units in the basalt strata giving Lambert coordinates, water pressure, and other similar well information. It was also designed to handle site characterization, hydrological, hydrochemistry, stratigraphy, and constituent data. There is some overlap between the capabilities of the Hanford groundwater data base and the BWIP technical data system. The BWIP technical data system is not intended for shallow wells in the unconfined aquifer.

The warehouse inventory management system is a data base established to track, from receipt of material to its shipment to the customer, all stock items and to forward costing data to the financial data system. For the purpose of safe storage and transportation, hazardous materials are identified within the warehouse inventory management system. The system will be used in conjunction with the material safety data sheet system and the SARA Title III program.

The Flow Gemini--environmental information system, managed by the HEHF, is commonly referred to as the HEX system. It is set up to contain information associated with onsite monitoring of exposures to hazardous materials of Hanford workers. This system is in the process of being modified, so there is considerable flexibility to adjust it to accommodate the onsite monitoring needs of the environmental restoration program.

The Flow Gemini--occupational health information system (HEHF's medical information tracking system) contains the confidential employee medical evaluation and history information. The HEHF medical surveillance program will need to be given directions from the HASP for each operable unit as to the specific elements that will need to be tracked for the specific individuals involved with its characterization. Once this is done, the medical information tracking system will contain all of this information.

The material safety data sheet system contains information on chemicals found at the Hanford Site. Currently, this is a manually operated system operated by HEHF; however, it is in the process of being computerized. The computerization effort is being done in coordination with the SARA Title III mandated "right-to-know" program at the Hanford Site.

The occupational radiation exposure data base system contains personnel respiratory protection fitting and qualifications, work restrictions, and radiation exposure information for all Hanford Site employees. Access to individual employee's records must be tightly controlled to comply with the Privacy Act of 1974.

The quality control blind standards data base contains information associated with quality control spiked samples, replicate sampling, and interlaboratory comparison results for the Hanford Site RCRA program. The data base is currently a manually tracked system, but is in the process of being computerized. It can quite readily be expanded to handle these type of data for the environmental restoration program as well.

The training records information system contains training records for Westinghouse Hanford employees. Currently it handles contractors to Westinghouse Hanford manually, but is in the process of being upgraded to handle these electronically. The training records information system can be adjusted to include all contractor personnel working on a particular operable unit.

The financial tracking system contains financial records for tracking and reporting on status of projects at Westinghouse Hanford. It is the system Westinghouse Hanford uses to track the financial aspects of all their projects. It has the capability of tracking projects by cost accounts and can provide status reports upon request.

Data management procedures are addressed in Chapter 4 of EPA guidance (1988a). The contents of Table 4-2 of Section 4.2.1.3, which provides an outline of the file structure necessary for a superfund site, were used as a list of elements necessary for a data management system. Table 8-3 shows a listing of these elements and a brief discussion of how the various components of the DMS will address them.

The previous discussions have addressed the existing systems that can be used to provide a historical basis for the RI/FS work. However, there are

Table 8-3. Analysis of Data Needs as Specified in the U.S. Environmental Protection Agency Draft Guidance Directive and Current Historical Hanford Site Data Bases. (Sheet 1 of 2)

File structure/data needs	Applicable data bases
Congressional Inquires and Hearings: Correspondence Transcripts Testimony Published hearing records	None available. These will have to be addressed by written procedures.
Discovery: Initial investigation Preliminary assessment Site inspection report Hazard ranking system data	Waste information data system and hanford inactive site survey. The Hanford inactive site survey contains hard copy files of the information used for performing the hazard ranking system/modified hazard ranking system evaluations of Hanford waste sites.
Remedial Planning: Correspondence Work plans for remedial investigation/feasibility study Remedial investigation/feasibility study reports Health and safety plan Quality assurance/quality control plan record of decision/responsiveness summary	The commitment control system is presently available to track correspondence. Health and safety plans and quality assurance/quality control plans will be included in each work plan that will be developed for each operable unit. The information pertinent to the development of the remedial investigation/feasibility study report will be tracked by the Hanford environmental information system using subordinate data bases such as the: Hanford groundwater data base, program data management system, waste information data system, Hanford inactive site survey, sample preparation system, BWIP technical data system, warehouse inventory management system, Flow Gemini--environmental information system, and quality control blind standards data base.
Remedial Implementation: Remedial design reports Permits Contractor work plans and progress reports U.S. Army Corps of Engineers agreements, reports, and correspondence	All of these items will be tracked by the data management system.
State and Other Agency Coordination: Correspondence Cooperative agreement/ superfund State contract Interagency agreements Memorandum of understanding with the State	Parts of these may be able to be tracked by the Hanford environmental compliance report. A record-file system is also currently being developed at the Hanford Site to track many of these items. These will be managed within the data management system.

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Table 8-3. Analysis of Data Needs as Specified in the U.S. Environmental Protection Agency Draft Guidance Directive and Current Historical Hanford Site Data Bases. (Sheet 2 of 2)

File structure/data needs	Applicable data-base system
Community Relations: Interviews Correspondence Community relations plan List of people to contract, e.g., local officials, civic leaders, environmental groups Meeting summaries Press releases News clippings Fact sheets Comments and responses Transcripts Summary of proposed plan Responsiveness summary	There is no known existing system at the Hanford Site available to electronically track community relations information. This information will be handled manually in accordance with the community relations plan with tracking added to the data management system.
Imagery: Photographs Illustrations Other graphics	The Hanford inactive site survey and associated files contain photographs and maps of sites. Also, the Hanford Environmental Information System will have graphic information system capabilities.
Enforcement: Status reports Cross-reference to any confidential enforcement files and the person to contact Correspondence Administrative orders	The Hanford environmental compliance report and environmental compliance tracking system will be used to contain the compliance status information by operable unit. Any administrative orders that are formally produced can also be tracked in the data management system designed to track formal documents.
Contracts: Site-specific contracts Procurement packages Contract status notifications List of contractors	Other than existing project management software systems currently available at the Hanford Site, there is no known electronic system presently available to track contract information such as this. This information can be handled manually by procedures or the data management system can track it.
Financial Transactions: Cross-reference to other financial files and the person to contact Contractor cost reports Audit reports	The financial operations for the cleanup of a Federal facility is different from the normal U.S. Environmental Protection Agency-funded superfund process. The financial information that needs to be tracked for compliance purposes can be tracked manually or by the data management system.

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several data management needs identified in Table 8-1 for which there is no currently operated or historical data base. These include the following:

- Geophysical (site-by-site basis)
- Soil column analytical data (site-by-site basis)
- Pilot- and bench-scale testing
- ARAR screening
- Cost tracking
- Calibration tracking
- Instrument coordination
- QA/QC tracking
- Field and laboratory notebook tracking
- Document tracking (both site-specific documents and guidance documents)
- Treatment/alternative screening
- Summarized/analyzed data (involves most of the raw data types).

Initial development of HEIS will focus on these needs in the order listed.

9.0 COMMUNITY RELATIONS PLAN

A community relations plan is currently being developed for the Hanford Site environmental restoration program. Because community relations activities are so interrelated among operable units, a decision was made to develop a single community relations plan that will have the capability to address specific individual concerns associated with each operable unit, but will still provide continuity and general coordination of all the environmental restoration program activities with regard to community involvement. The site-wide community relations plan discusses Hanford Site background information, history of community involvement at Hanford, and community concerns regarding the Hanford Site. It also delineates the community relations program that the DOE-RL, the EPA Region 10 Office, and Ecology will cooperatively implement throughout the cleanup of all the operable units at the Hanford Site. All community relations activities associated with the 1100 Area work plan will be conducted under this overall Hanford Site community relations plan.

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APPENDIX A

SITE DESCRIPTION

APPENDIX A

SITE DESCRIPTION

1.0 INTRODUCTION

Appendix A provides a brief summary of available information on geology, hydrogeology, surface hydrology, meteorology, air quality, and ecology of the 1100 Area. Because relatively little site-specific information is available, the information presented below is based primarily on regional data and extrapolation from other areas on the Hanford Site.

2.0 GEOLOGY

The 1100 Area lies on an elongated north-south plateau at an elevation of approximately 400 ft above mean sea level, between the Yakima and Columbia Rivers, which are at elevations of approximately 370 ft and 340 ft, respectively. The land surface slopes generally to the southwest toward the Yakima River and to the east toward the Columbia River. The area is located on the southern extension of the Central Hanford Sand Plain, which is part of the central plains geomorphic unit of the Columbia Plateau. Southwest-to-northeast-trending longitudinal dunes extend up to or across the 1100 Area. The amplitude of most of the dunes is on the order of 10 ft. The dunes are locally active, but for the most part they have been stabilized by vegetation or have been reworked in grading and excavation for facilities.

The principal structural feature is the Pasco Basin (Fig. A-1), which is one of several sediment-filled basins in the Central Columbia Plateau. The sediments in the Pasco Basin, as well as of the entire Columbia Plateau, are underlain by the Miocene age Columbia River Basalt Group. The sediments overlying the basalts, from the basalts upward, include (1) the Ringold Formation, (2) glaciofluvial deposits of the Hanford formation, which include Pasco gravels and Touchet Beds, and (3) surficial eolian sediments. Figure A-2 illustrates suprabasalt stratigraphy in the Pasco Basin. Direct evidence as to the depth, thickness, and characteristics of sediments and basalts beneath the 1100 Area is limited. The description presented below is based primarily on a log for a test well north of the Horn Rapids landfill and on extrapolation of geologic conditions from the 300 Area.

2.1 COLUMBIA RIVER BASALT GROUP

Basalts of the Columbia River Basalt Group are present below a depth of approximately 170 to 200 ft. Comprised of numerous basalt flows and interbedded sediments, the Columbia River Basalt Group extends more than 12,000 ft below the Hanford Site (DOE 1986).

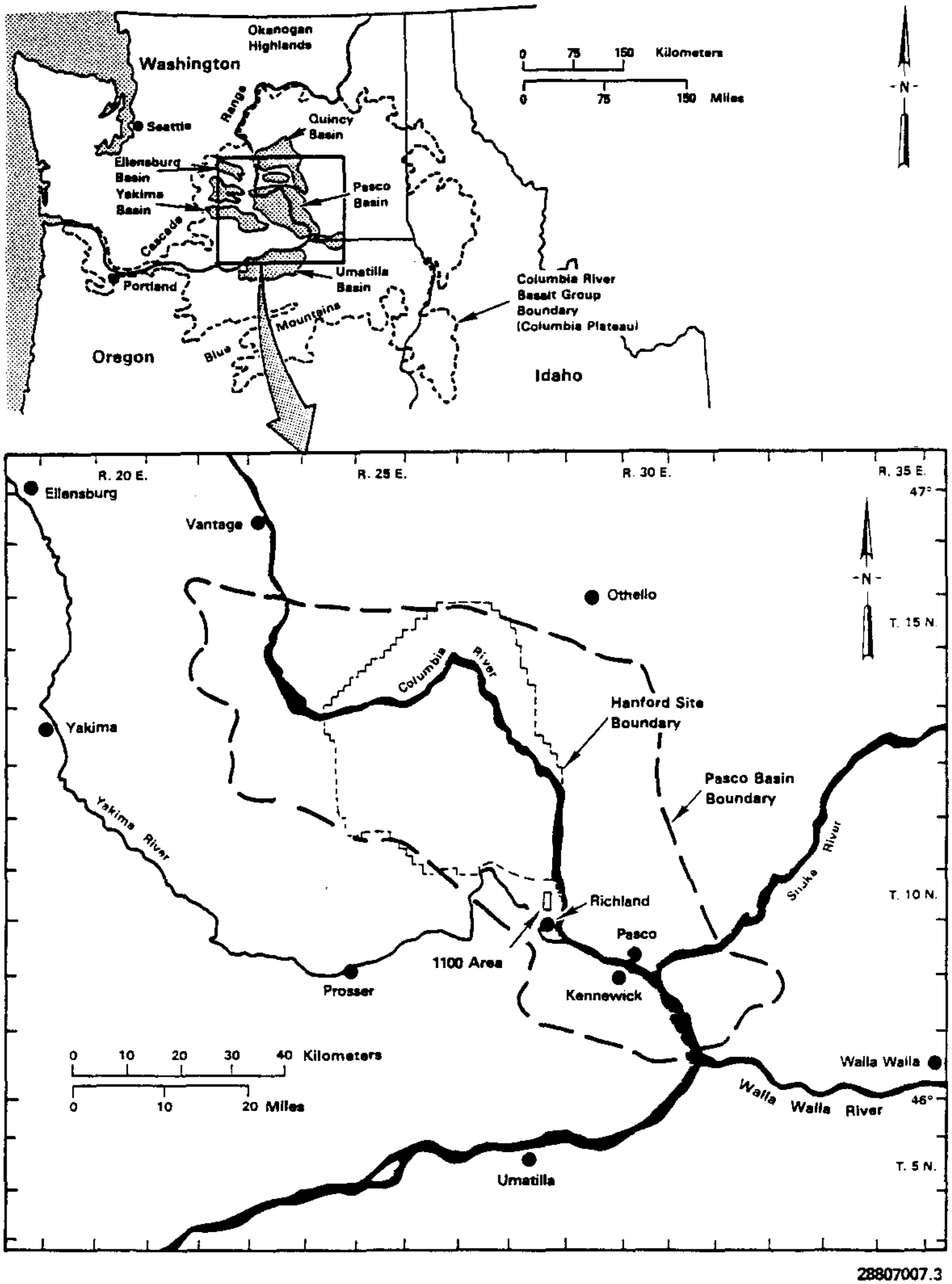


Figure A-1. Location of 1100 Area Within Pasco Basin.

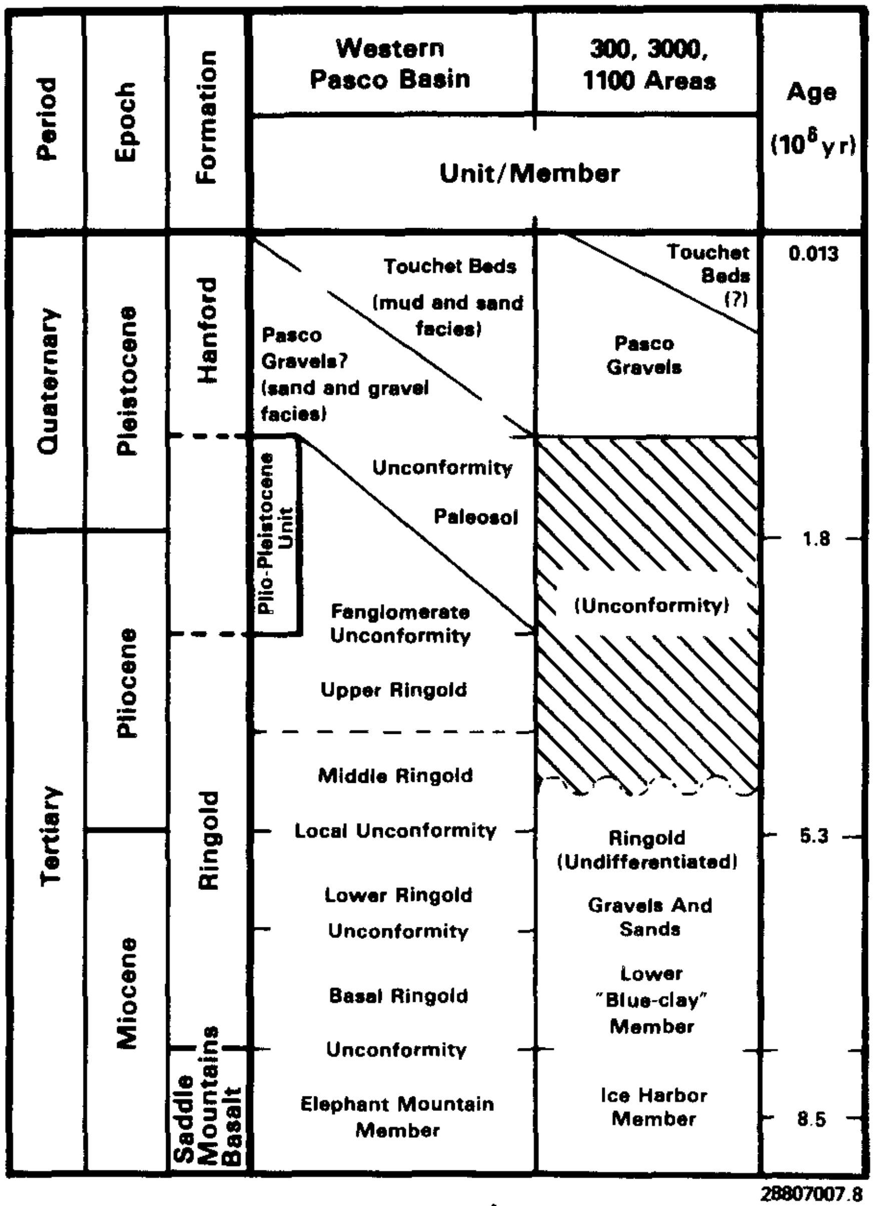


Figure A-2. Suprabasalt Stratigraphy of the Pasco Basin.

2.2 RINGOLD FORMATION

The Ringold Formation directly overlies the uppermost basalt flows of the Columbia River Basalt Group. The Ringold is a fluvial sedimentary unit that exhibits lateral facies variations. Major facies of the Ringold Formation include the main river channel facies, overbank facies, and fanglomerate facies. Figure A-3 shows the general distribution of Ringold facies types within the Pasco Basin. Because of the facies variations and limited data, the stratigraphic relationship between Ringold units observed in the 3000, 300, and 1100 Areas and well-studied sections in the western Pasco Basin is not completely known.

Newcomb (1958) divided the Ringold Formation into three members, based on exposures at the type section along the southern end of the White Bluffs (located along the Columbia River at the east side of the Hanford Site). These are a "lower blue clay member," a "middle conglomerate member," and an "upper member." The "lower blue clay member" (now called the lower Ringold unit) is now known to overlie, in some areas of the Hanford Site, a thin basal Ringold unit composed of clay to gravelly sand. The lower unit itself is generally a clay or silt that often contains sandy or gravelly layers (Newcomb et al. 1972). The middle Ringold unit is generally a sandy gravel with local sand or silt lenses. The upper Ringold unit, found mainly in the White Bluffs area to the north and across the Columbia River from the 300 Area, is composed mainly of fine sand and silt.

A complete section of the Ringold Formation is probably not present in the vicinity of the 1100 Area. In the 300 Area, approximately 2 mi north of the 1100 Area, the upper unit and part of the middle unit have been removed by erosion prior to deposition of the Pasco Gravels (Lindberg and Bond 1979). This is probably the case in the 1100 Area also. In the 1100 Area the lower Ringold unit (and the basal unit if present) lie completely beneath the water table. The water table lies within the uppermost portion of the Ringold Formation present (the middle Ringold unit) or within the lowermost portion of the Pasco gravels. Total thickness of the Ringold Formation in a test well (10/29-10G1) approximately 0.5 mi north of the Horn Rapids landfill is approximately 144 ft (Newcomb et al. 1972). The lower 23 ft correspond to the "lower Ringold unit" discussed above, while the remaining thickness consists primarily of gravel, gravelly sand, sand, and silty sand, with occasional interbeds of clay and siltstone. In the 300 Area, the Ringold Formation present is approximately 150 ft thick with the lower Ringold unit about 40 ft (Lindberg and Bond 1979).

2.3 PASCO GRAVELS

Glaciofluvial deposits known as the Pasco gravels overlie the Ringold Formation and extend to very near the surface. These gravels were deposited by Pleistocene floodwaters resulting from catastrophic failure of ice dams in western Montana and northern Idaho. The Pasco gravels were deposited on an irregular erosional surface along main channelways of the catastrophic floods. Thickness of the gravels varies from 30 ft to more than 50 ft.

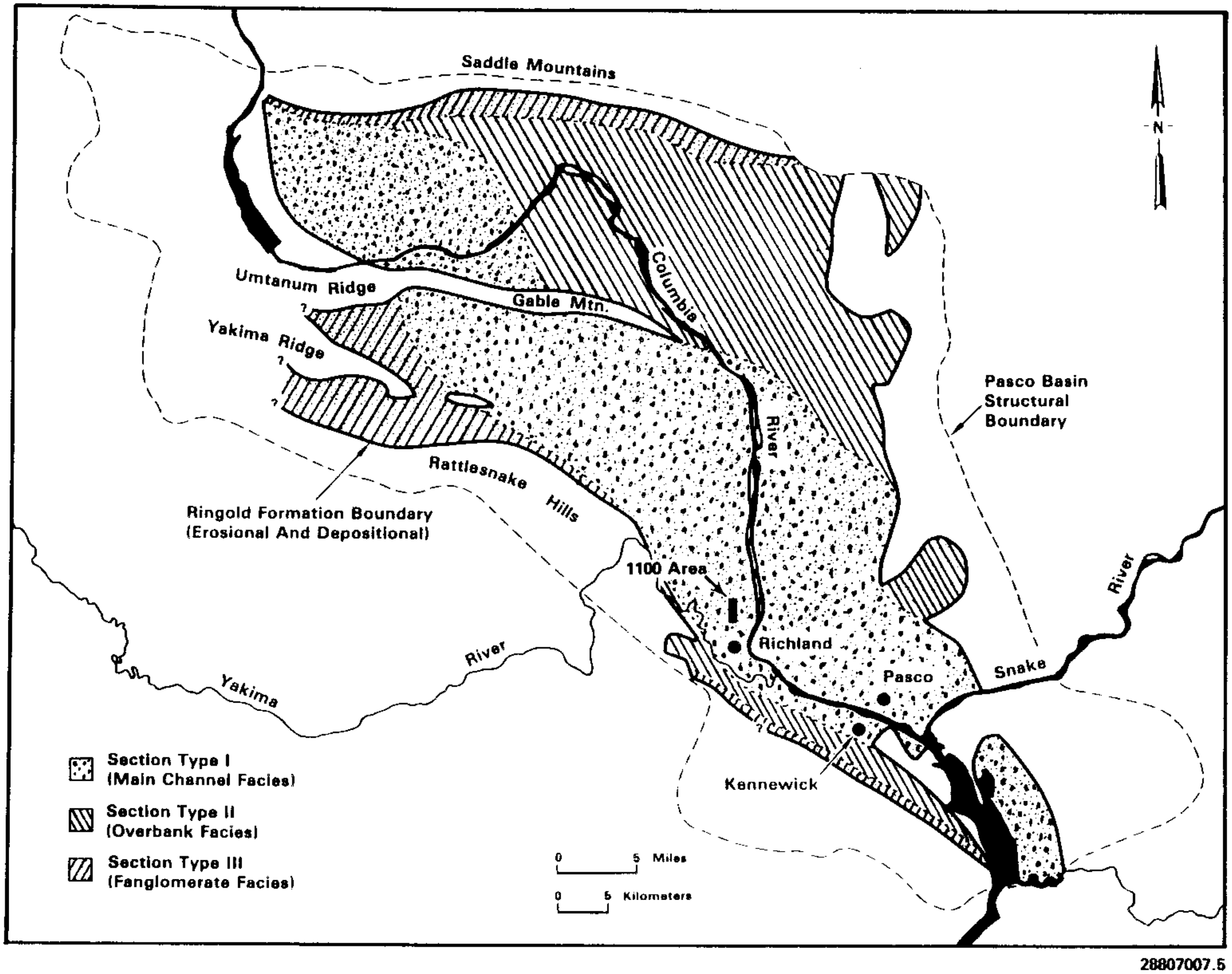


Figure A-3. Distribution of Ringold Facies Types in the Pasco Basin.

Touchet beds are rhythmically bedded, fine-grained slack water flood facies that are generally contemporaneous with the Pasco gravels. Because the 1100 Area lies along a main flood channelway (Fig. A-4), Touchet beds are not expected to constitute a significant part of the stratigraphic section within the 1100 Area.

A total thickness of 47 ft for "glaciofluviatile and fluviatile deposits," corresponding to the Pasco gravels is reported in well 10/28-10G1 (Newcomb et al. 1972). These deposits consist of sandy gravel with boulders, in which the predominant lithology of the gravel and boulders is generally basalt.

2.4 SURFICIAL EOLIAN SEDIMENTS

Eolian sands and silts cover the area as a veneer of varying thickness. These deposits consist of fine to medium sand or silty sand.

3.0 HYDROGEOLOGY

Groundwater beneath the area occurs in confined aquifers within the basalt sequence, the unconfined aquifer of the Pasco gravels, and the sands and gravels of the Ringold Formation. The boundary between the confined and unconfined aquifers in the 300 Area is typically the lowermost silt and clay member of the Ringold Formation (Lindberg and Bond 1979). In the 300 Area a confined aquifer may exist in gravel layers beneath the silt/clay member and immediately above the basalt. The estimated depth to the water table in the vicinity of the 1100 Area is approximately 40 to 60 ft. Because of lateral facies variations, silt or clay lenses in the Ringold Formation may function as aquitards on a local scale. Perched or semiperched water conditions may also occur locally.

The unconfined aquifer in the area exhibits relatively high permeability, particularly in the Pasco gravels. Aquifer pumping tests and numerical groundwater modeling for the 300 Area indicate transmissivities greater than 100,000 ft^2/d (Lindberg and Bond 1979). The storativity of the unconfined aquifer has been estimated to be 0.1 for hydrologic studies of the 300 Area (Lindberg and Bond 1979). Aquifer tests conducted in the north Richland well field (ICF 1987) indicate a transmissivity of approximately 86,000 ft^2/d, and storativity of 0.11. No measurements of these parameters or of the dispersive or retardation characteristics of these aquifers beneath the 1100 Area are available. However, because the sediments in the unconfined aquifer are similar to those in the 300 Area and the north Richland well field, hydrologic properties of sediments in the 1100 Area are probably similar.

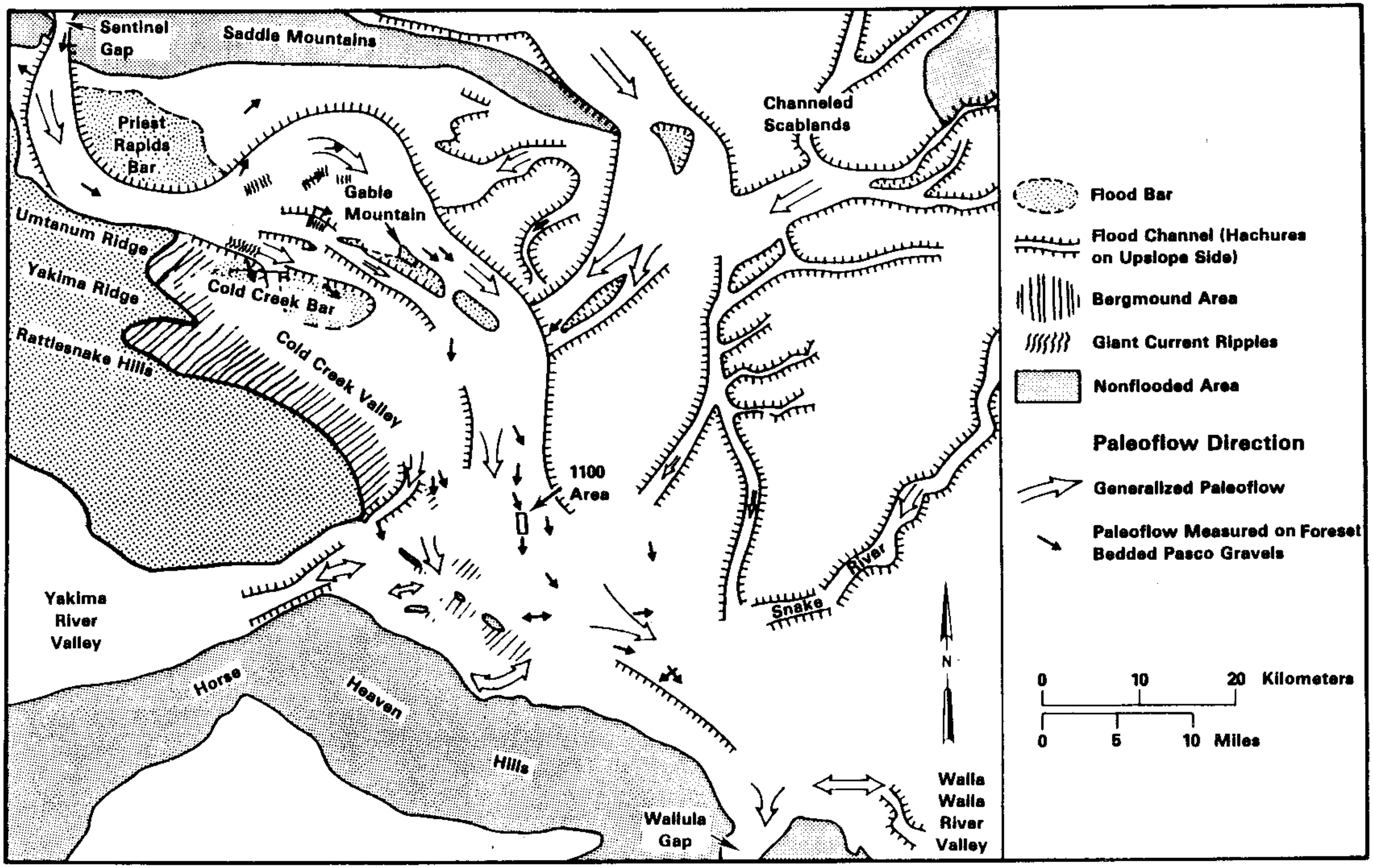


Figure A-4. Pleistocene Flood Channels.

Water-table maps for the Hanford Site indicate that along the northern end of the 1100 Area, the water table dips to the east and ranges from approximately 370 to 350 ft above mean sea level (WHC 1987). Regional groundwater flow in the 1100 Area is thought to generally be west to east, controlled by the elevation difference between the Yakima and Columbia Rivers. The Yakima River is recharging the unconfined aquifer, which in turn discharges to the Columbia River. There are a number of factors that potentially complicate this relatively simple system:

- Spatial differences in hydraulic conductivity of the unconfined aquifer
- Variations in the river stage of both the Yakima and Columbia Rivers
- Infiltration to the unconfined aquifer from irrigation (agricultural and residential)
- Upward leakage (discharge) from the confined aquifer to the lower part of the unconfined aquifer
- Operation of the north Richland well field (including the artificial recharge of Columbia River water to the unconfined aquifer)
- A water table that sometimes lies within the higher permeability Pasco gravels and in other areas within the lower permeability Ringold Formation.

Of these factors, the operation of the north Richland well field is likely the most significant.

Variations in stage of the Columbia River are expected to have minimal effects on groundwater flow in the 1100 Area and vicinity because of the high degree of control by Columbia River dams. Newcomb et al. (1972, p. 27) discuss significant effects of varying river stage on the water table near the Columbia River at Richland. However, their data were collected from January 1950 to December 1952 and correspond to a time before Priest Rapids (upstream), McNary (downstream), and other dams were constructed. The 1100 and 300 Areas are now near the upper reaches of the McNary Pool, which is maintained at a fairly constant elevation of 339 to 344 ft.

Newcomb et al. (1972, p. 27) report a 22-ft rise in Columbia River level near Richland in 1950 that resulted in a 14-ft rise of the water level in a well 4,000 ft from the Columbia River. Lindberg and Bond (1979, p. 4-23 to 4-31) report that in 1977 (post-dam construction) the Columbia River rose 3.6 ft at the 300 Area and resulted in a 2-ft rise in a well 1,300 ft from the Columbia River (well 699-S30-E15A) and a less than 1-ft rise in a well 4,000 ft from the Columbia River (699-S29-E12). The north Richland well field is 3,000 to 4,000 ft from the Columbia River, and the 1100 Area is 6,000 to 7,000 ft from the Columbia River.

The high river stages reported by Newcomb et al. (1972) at Richland in the early 1950s were sustained for 2 to 3 mo each time, whereas the high water stage reported by Lindberg and Bond (1979) at the 300 Area during 1977 lasted less than 1 mo. One month is not enough time for significant effects of a higher river stage to propagate in the groundwater more than approximately 4,000 ft from the Columbia River.

Halfway between the 1100 Area and the Columbia River is the city of Richland's north Richland well field. The wells are completed in the unconfined aquifer and are artificially recharged by water pumped from the Columbia River to infiltration ponds. Artificial recharge is conducted during the summer months and during the winter when the water treatment plant is shut down. The well field is used for city water-supply makeup during peak demand periods and when the water treatment plant is shut down for maintenance. Intermittent operation of the well field and recharge ponds likely causes significant local fluctuation of the water table and substantially affects the rate and direction of groundwater flow in the vicinity of the 1100 Area.

Given the heterogeneity of both the Pasco gravels and the Ringold Formation, together with the various recharge/discharge points and seasonal variations in withdrawal, the groundwater flow conditions in the 1100 Area are likely to be complex, and direction and rate of groundwater flow is likely to change with time.

4.0 SURFACE HYDROLOGY

The major surface water features at the Hanford Site are the Columbia River, which is located approximately 1 mi east of the 1100 Area, and the Yakima River, about 2 mi to the west. Both streams are important sources of industrial, agricultural, and domestic water for the region. Other streams in the vicinity of the 1100 Area are ephemeral. No surface water or ephemeral streams are present within the 1100 Area or the Horn Rapids landfill. Abandoned irrigation canals pass through the 1100 Area at several locations. These canals have not been used since the land was taken over by the U.S. Government in the 1940s.

Mean annual precipitation within the Pasco Basin ranges from less than 7 in. within the Hanford Site to a maximum of 15 in. atop Rattlesnake Mountain (located to the west-northwest of the 1100 Area). Total annual precipitation over the entire basin is estimated to be approximately 800,000 acre-ft, with an average annual precipitation of less than 8 in. Mean annual runoff is generally less than 0.5 in. for most of the basin (Leonhart 1979).

Average annual pan evaporation exceeds 60 in. Average annual lake evaporation ranges from 39 to 41 in. Actual evapotranspiration is essentially equivalent to annual precipitation (Leonhart 1979). Each of the individual sites in the 1100 Area is characterized by interior drainage, such that significant surface runoff is unlikely.

5.0 METEOROLOGICAL CONDITIONS AND AIR QUALITY

A comprehensive program of meteorological monitoring is in place at the Hanford Site. Meteorological data are collected at the Hanford Meteorological Station and at 24 automated monitoring stations (Fig. A-5) located within the Hanford Site and in adjacent areas. The Hanford Meteorological Station is located approximately 21 mi northwest of the 1100 Area, between the 200 East and 200 West Areas. Since 1945, meteorological measurements have been made at the station and at multiple levels on its 400-ft instrumented tower. Earlier measurements of temperature and precipitation, beginning in 1912, were made at the old Hanford townsite. A summary of these data, through 1980, has been published by Stone et al. (1983).

Two of the automated stations in the meteorological monitoring network are located within close proximity to the 1100 Area. These monitoring sites have been in operation since early 1982. The 300 Area monitoring site is located less than 1 mi north-northeast of the Horn Rapids landfill and approximately 3 mi north of the 1171 Building. At this station, measurements of wind direction and speed and of air temperature are made at three levels on a 200-ft meteorological tower. A doppler acoustic sounder is also located at this site. The sounder remotely senses wind directions and speeds, air temperatures, and other parameters to a height of up to 1,800 ft above the surface.

The second of these two stations is located about 2 mi to the south-southwest of the 1100 Area at the Richland Airport. At this monitoring site, wind and temperature sensors are mounted on the top of the airport's air-traffic control tower. Measurements are made at a height of approximately 50 ft above ground level.

The Horn Rapids landfill is located in the same general terrain environment as the 300 Area monitoring site; meteorological conditions at this disposal site should be adequately represented by measurements at the 300 Area station. The other disposal sites in the 1100 Area are located further to the south, between the Richland and 300 Area stations. Therefore additional meteorological monitoring will be required to determine how representative the existing meteorological monitoring sites are of conditions in the central and southern portions of the 1100 Area.

Meteorological data collected at the automated stations are communicated by radio to the Hanford Meteorological Station in the form of 15-min averaged values. After being received at the Hanford Meteorological Station, data are processed and stored on a minicomputer for later analysis.

5.1 NEAR-SURFACE WINDS

At the 300 Area site, the winds are most frequently out of the north, although winds from the southeast through the southwest also occur fairly frequently. At the Richland Airport site, the winds are most frequently from the southwest; winds from the west, west-southwest, and south-southwest are next in order of frequency. At both sites, winds with an easterly component

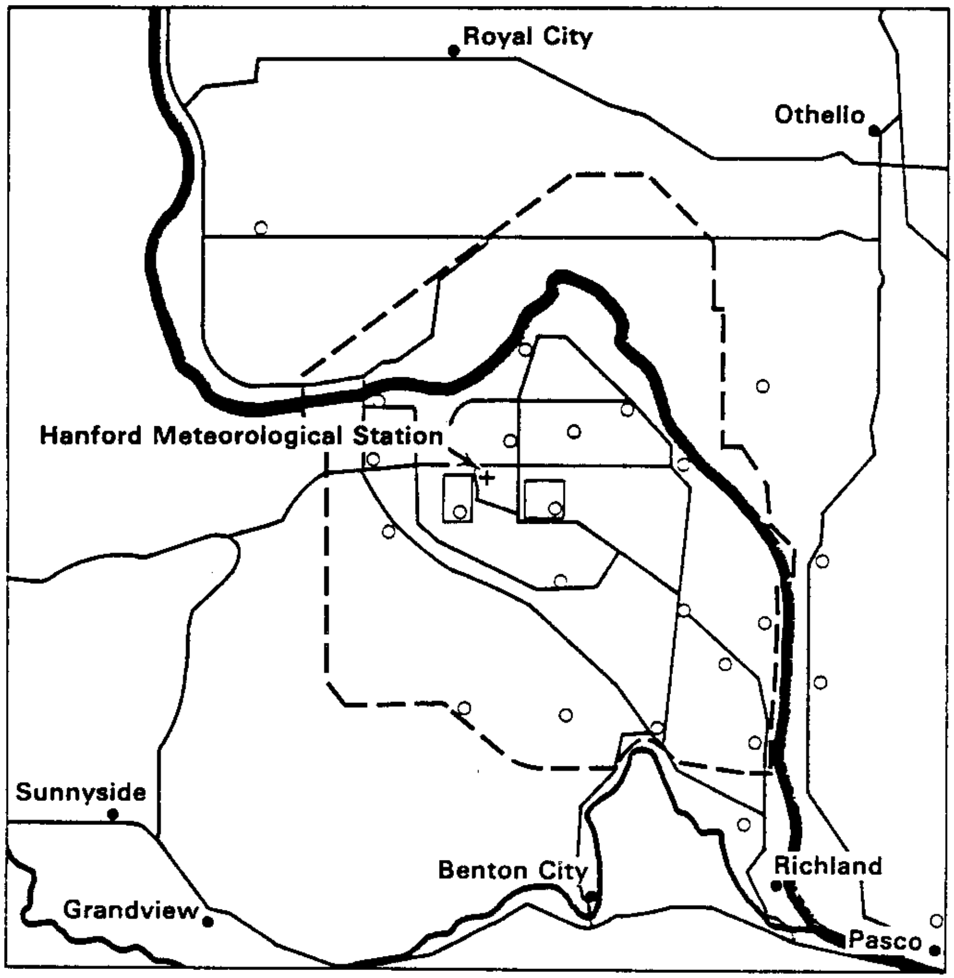


Figure A-5. Location of the Hanford Meteorological Station and Automated Monitoring Stations on the Hanford Site and in the Surrounding Area.

tend to have significantly lower wind speeds than winds with a westerly component. Also at both sites, winds with the highest speeds tend to be from the southwest. Wind roses for both sites are presented in Figure A-6.

There are some significant differences in the wind patterns for the 300 Area and Richland Airport monitoring sites. These differences arise because of the influence of local terrain, vegetation, and nearby buildings on winds. The 300 Area site is located on a slight rise (a stabilized sand dune) less than 1 mi west of the Columbia River. The site is located in a north-south running river valley; the terrain to the west begins a gradual increase in elevation a little over 1 mi from the site, and the terrain to the east rises steeply on the east bank of the Columbia River. This terrain configuration should account for the high percentage of low speed winds with strong northerly and southerly components at the 300 Area station.

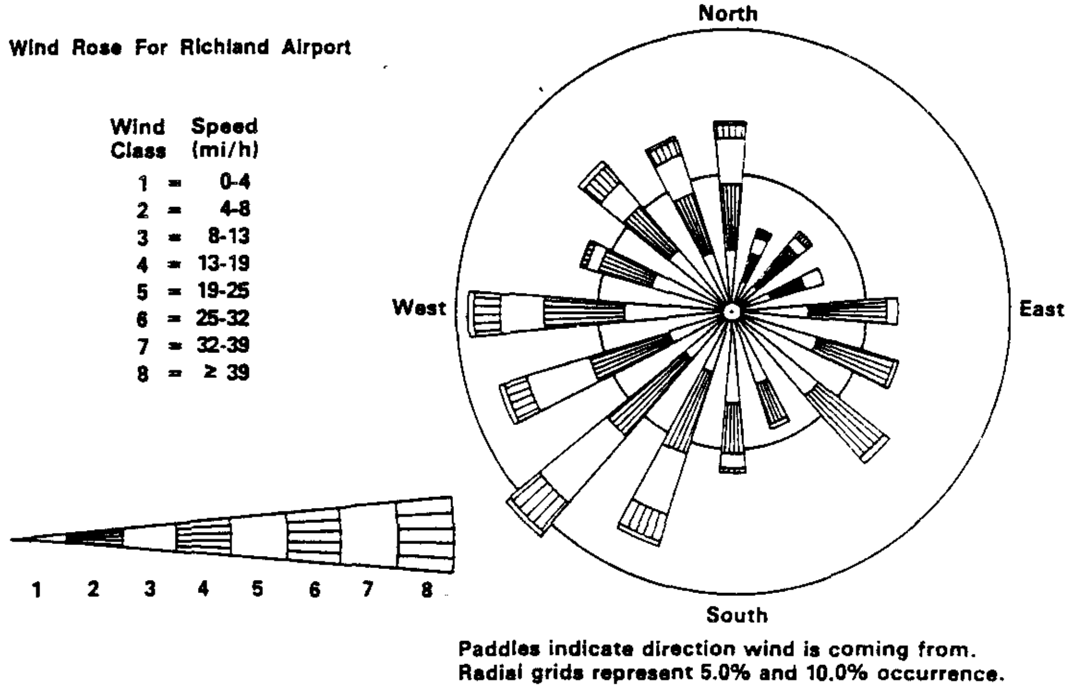
Measurements of the wind at the Richland Airport site are made at a slightly higher distance above the ground than at the 300 Area site. Airport buildings, of comparable height to the control tower, are located to the southwest of the wind sensors. The northwestern edge of the city of Richland and its surrounding shelterbelt of trees approach to within 1,000 ft of the site. The airport buildings and the city's trees and buildings should have some affect on the meteorology of this site. However, at the airport there are no significant variations in the elevation of the local terrain to influence winds, as at the 300 Area site.

5.2 TEMPERATURE AND HUMIDITY

Diurnal and monthly averages and extremes of temperature, dewpoint, and humidity are contained in Stone et al. (1983). For the period 1912 through 1980, the average monthly temperatures range from a low of 29.3 °F in January to a high of 76.4 °F in July. During the winter, the highest monthly average temperature at the Hanford Meteorological Station was 44.5 °F, and the record lowest was 21.4 °F; both occurred during February. During the summer, the record maximum monthly average temperature was 81.8 °F in July, and the record low was 63.0 °F in June. The annual average relative humidity at the Hanford Meteorological Station is 54%, with maxima during the winter months (averaging around 75%) and minima during the summer (about 35%).

5.3 PRECIPITATION

Average annual precipitation at the Hanford Meteorological Station is 6.3 in. Most of the precipitation takes place during the winter, with nearly half of the annual amount accruing in the months of November through February. Days with greater than 0.5 in. precipitation occur less than 1% of the year. Rainfall intensities of 0.2 in/h persisting for 1 h are expected once every 10 yr. Rainfall intensities of 1 in/h for 1 h are expected only once every 500 yr. Winter monthly average snowfall ranges from a minimum of 0.3 in. in March to a maximum of 5.3 in. in January.



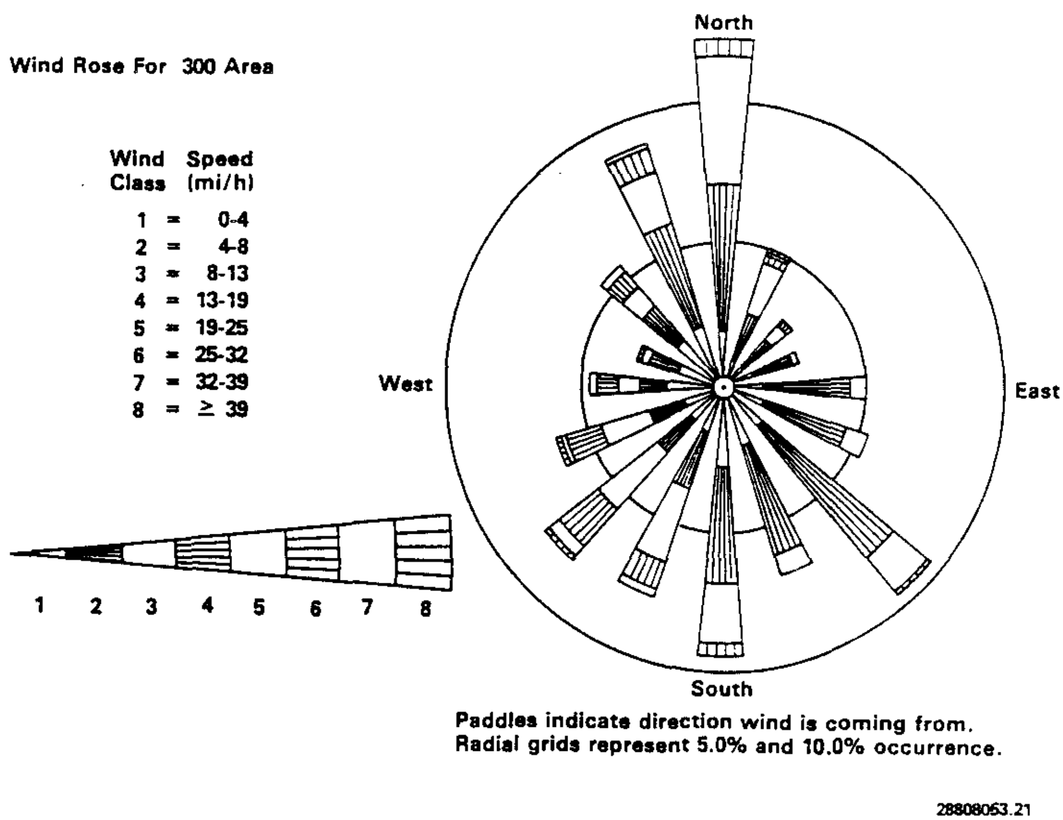


Figure A-6. Wind Roses for Richland Airport and the 300 Area.

5.4 ATMOSPHERIC DISPERSION

Atmospheric dispersion is a function of wind speed, atmospheric stability, and mixing depth. Dispersion conditions are generally good when winds are moderate to strong, when the atmosphere is neutral or unstably stratified, and when there is a deep mixing layer. Good dispersion conditions associated with neutral and unstable stratification exist about 57% of the time during the summer. Less favorable dispersion conditions occur when the wind speed is light and the mixing layer is shallow. These conditions are most common during the winter, when moderately to extremely stable stratification exists about 66% of the time.

Occasionally there are extended periods of poor dispersion conditions that are associated with stagnant air in stationary high-pressure systems. Stone et al. (1972) estimated the probability of extended periods of poor dispersion conditions. The probability of an inversion period extending more than 12 h varies from a low of about 10% in May and June to a high of about 64% in September and October. These probabilities decrease rapidly for durations greater than 12 h.

5.5 AIR QUALITY

Sulfur dioxide, nitrogen dioxide, carbon monoxide, and total suspended particulates have been periodically monitored in the communities and commercial areas southeast of the Hanford Site, and/or sites within the Hanford Site, during the past two decades. The maximum ambient concentrations measured in the region are presented in Table A-1. Because these measurements were taken near local sources of pollution and during periods when pollutant emission rates were higher than current levels, these values are estimated to be higher than current maximum background concentrations.

Currently, air concentrations of nitrogen dioxide and total suspended particulates are routinely monitored on the Hanford Site. This monitoring indicates that the maximum annual average concentrations of nitrogen dioxide are less than 15 $\mu g/m^3$. Local monitoring of total suspended particulates for the Tri-County Air Pollution Control Board is conducted at the Hanford Meteorological Station. State-wide monitoring indicates that the concentrations of total suspended particulates periodically reach relatively high levels in eastern Washington, due to natural events (i.e., dust storms, sand storms, volcanic eruptions, and large brush fires). Accordingly, high levels of total suspended particulates have been measured at the Hanford Meteorological Station during such events. "Rural fugitive dust" from such natural events is typically exempted from regulatory consideration.

Table A-1. Ambient Air Quality Standards and Maximum Measured Background Concentrations for the Hanford Site and the Surrounding Area ($\mu g/m^3$).

Concentration monitored	National primary standard	National secondary standard	Supplemental state standard	Maximum ambient concentration
Nitrogen dioxide				
Annual arithmetic mean	100	100	--	36
Sulphur dioxide				
Annual arithmetic mean	80	80	52	0.5
24-h maximum[a]	365	365	260	6
3-h maximum[a]	--	1,300	--	20
1-h maximum[a]	--	--	1,018	49
1-h maximum[b]	--	--	655	49
Carbon monoxide				
8-h maximum[a]	10,000	10,000	--	6,500
1-h maximum[a]	40,000	40,000	--	11,800
Total suspended particles				
Annual geometric mean	75	60	40 + bkgd.[c]	55/20[d]
24-h maximum[a]	260	150	120 + bkgd.[c]	353/30[d]

[a]Not to be exceeded more than once per year.
[b]Not to be exceeded more than two times in any consecutive 7 d.
[c]bkgd. = background concentration caused by natural sources.
[d]The higher values represent concentrations caused by the occurrence of exceptional natural events (i.e., duststorms, brushfires). In the absence of duststorms and other natural events, the maximum annual background concentration would generally not exceed 20 $\mu g/m^3$ and the maximum 24-h background concentration would generally not exceed 30 $\mu g/m^3$. For siting and enforcement purposes, the U.S. Environmental Protection Agency uses these lower values for eastern Washington.

6.0 BIOTA

6.1 VEGETATION

The natural vegetation of the gently sloping land between the Rattlesnake Hills and the western shore of the Columbia River is dominated by desert shrubs, especially big sagebrush, bitterbrush, rabbitbrush, and, to a lesser degree, spiny hopsage. The herbaceous understory to the shrubs is mostly dominated by grasses, especially cheatgrass (an alien annual species introduced to eastern Washington from Eurasia in the late 1800s) and the small native bunchgrass, Sandberg bluegrass. The invasion of cheatgrass has been attributed to the effects of livestock grazing for many decades before 1943 (Mack 1981). The predominant vegetation type on land areas affected by waste management activities is the sagebrush-cheatgrass *(Artemisia tridentata - Bromus tectorum)*.

The abandoned agricultural fields have been dominated by alien annual plants, such as cheatgrass and Russian thistle, for four decades, with little evidence of invasion by the native perennial plants.

6.2 TERRESTRIAL ANIMALS

The most extensive terrestrial animal habitat on the Hanford Site is the sagebrush-grass habitat type. The game mammals on the Hanford Site are the mule deer, cottontail, and jackrabbit. The fur-bearers are the coyote, badger, and bobcat.

Resident small mammals include the Great Basin pocket mouse, deer mouse, Townsend ground squirrel, pocket gopher, harvest mouse, house mouse, Norway rat, sagebrush mole, grasshopper mouse, vagrant shrew, least chipmunk, and Merriam shrew.

The game birds that may nest in the sagebrush-grass habitat type are the sage grouse, mourning dove, chukar partridge, and gray partridge. Hawks and owls use the Hanford Site as a refuge, especially during nesting (Fitzner et al. 1980). Raptors that nest on the Hanford Site include Swainson's hawk, red-tailed hawk, northern harrier, kestrel, prairie falcon, burrowing owl, and great horned owl.

Historically, the sagebrush-grass habitat has provided breeding sites for small birds and animals such as the horned lark, western meadowlark, and the Great Basin pocket mouse. An ever expanding use of land for irrigated agriculture, dryland wheat crops, and urbanization has resulted in substantial loss of sagebrush-grass habitat in eastern Washington. Although the land of the Hanford Site has not experienced the dramatic loss of sagebrush-grass habitat that has steadily occurred on the surrounding lands over the past four decades, some species of animals and plants that were abundant in sagebrush-grass habitats in the past have diminished in abundance to the point where they may in the near future become extirpated or extinct. Some species may require special kinds of management. Endangered and threatened plants and animals (as designated by both Federal and State of Washington agencies) that occur or are thought to occur on the Hanford Site are briefly reviewed in Tables A-2 and A-3.

Table A-2. Endangered, Threatened and Sensitive Plants on the Hanford Site.

Taxa	Status[a]	Relationship to the 1100 Area
Columbia Milk Vetch *Astragalus columbianus Barneby*	Threatened C[b]	A local endemic[c] with its major populations located on the Yakima Firing Center; not expected to occur in the vicinity of the 1100 Area
Persistent Sepal Yellowcress *Rorippa columbiae Suksd. ex Howell*	Endangered C	Known to occur on the wetted shoreline of the Columbia River on the Hanford Site; not likely to occur in the vicinity of the 1100 Area
Thompson's Sandwort *Arenaria franklinii Dougl. var. Thompsonii Peck*	Threatened	Exists as *A. franklinii* on stabilized sand dunes; taxonomic status is currently under consideration
Hoover's Desert Parsley *Lomotivum tuberosum Hoover*	Threatened C	A local endemic in Yakima, Benton, Grant, and Kittitas Counties, occurrence in the vicinity of the 1100 Area has not been established
Gray Cryptantha *Cryptantha leucophea Dougl. Pays*	Sensitive	Occurs on stabilized sand dunes of the Hanford Site near the Wye Barricade; occurrence in the vicinity of the 1100 Area has not been established
Piper's Daisy *Erigeron piperianus Cronq.*	Sensitive	A local endemic, occurs on the Arid Lands Ecology Reserve; occurrence in the vicinity of the 1100 Area has not been established
Tooth-Sepal Dodder *Cuscuta denticulata Engelm.*	Monitor	Recently found in Benton County; parasitic on sagebrush; may occur in the vicinity of the 1100 Area

[a]**Definitions of special classifications of vascular plants in Washington and special terminology:**

Endangered--A vascular plant taxon in danger of becoming extinct or extirpated in Washington within the near future if factors contributing to its decline continue. These are taxa whose populations are at critically low levels or whose habitats have been degraded or depleted to a significant degree.

Threatened--A vascular plant taxon likely to become endangered within the near future in Washington if factors contributing to its population decline or habitat degradation or loss continue.

Sensitive--A vascular plant taxon, with small populations or localized distribution within the state, that is not presently endangered or threatened, but whose populations and habitats will be eopardized if current land use practices continue.

Monitor--A vascular plant taxon of potential concern because of uncertain taxonomic status or paucity of information concerning distribution; or a taxon that is actually more abundant or less threatened than previously thought.

[b]Plants that are listed as "C" are candidates on the 1980 Federal Register Notice of Review and 1983 Supplement.

[c]Local endemic--A taxon restricted to a geographical area, usually within a single county or several adjacent counties.

Table A-3. Endangered, Threatened, and Sensitive Animals on the Hanford Site. (Sheet 1 of 2)

Taxa	Status[a]	Relationship to the 1100 Area
WASHINGTON STATE STATUS OF SPECIAL BIRD SPECIES		
Birds Associated with Dryland Habitats of the Hanford Site But Not Known to Nest on the Hanford Site		
Golden Eagle *Aquila chrysoaetes*	PS	Forages in sagebrush-grass habitats; mostly a winter visitor
Birds that are Infrequent Visitors to the Hanford Site		
Peregrine Falcon[b] *Falco peregrinus*	SE	An erratic visitor
Birds Associated with Sagebrush-Grass Habitats		
Ferruginous Hawk *Buteo regalis*	ST	An occasional forager in sagebrush-grass habitats; an occasional nester on the Arid Lands Ecology Reserve
Swainson's Hawk *Buteo swainsonii*	PS	Forages in sagebrush-grass habitats in spring and summer
Prairie Falcon *Falco mexicanus*	PS	Forages in sagebrush-grass habitats; a year-round resident
Burrowing Owl *Athene cunicularia*	PS	Forages in sagebrush-grass habitats
Sage Thrasher *Oreoscoptes montanus*	PS	A possible forager in sagebrush-grass habitats
Long-Billed Curlew *Numenius americanus*	PM	Nests in dryland habitats in the vicinity of the 1100 Area, mostly in spring and summer; forages in sagebrush-grass habitats
Sage Sparrow *Amphispiza belli*	PM	Nests in desert shrubs; forages in sagebrush-grass habitats in spring and summer
Sage Grouse *Centrocercus urophasianus*	c	A small population inhabits the Arid Lands Ecology Reserve
WASHINGTON STATE STATUS OF SPECIAL MAMMAL SPECIES		
Pygmy Rabbit *Sylvilagus idahoensis*	ST	An unlikely inhabitant of sagebrush-grass habitats in the 1100 Area; may be extirpated from the Hanford Site
Merriam's Shrew *Sorex merriami*	PS	An unlikely inhabitant of sagebrush-grass habitats in the 1100 Area; known to inhabit the Arid Lands Ecology Reserve
White-Tailed Jackrabbit *Lepus townsendii*	PS	An unlikely inhabitant of sagebrush-grass habitats in the 1100 Area; may be extirpated from the Hanford Site
Sagebrush Vole *Lagurus curtatus*	PM	An unlikely inhabitant of the sagebrush-grass habitats in the vicinity of the 1100 Area; more abundant on the Arid Lands Ecology Reserve
Northern Grasshopper Mouse *Onychomys leucogaster*	PM	Present in sagebrush-grass habitats
Ord Kangaroo Rat *Dipodomys ordii*	PM	Not known to inhabit the Hanford Site

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Table A-3. Endangered, Threatened, and Sensitive Animals on the Hanford Site. (Sheet 2 of 2)

Taxa	Status[a]	Relationship to the 1100 Area
WASHINGTON STATE STATUS OF SPECIAL MAMMAL SPECIES		
Townsend Ground Squirrel *Spermophilus townsendii*	PM	Locally abundant in sagebrush-grass habitats
Several species of bats may inhabit abandoned buildings. The Long-Eared Myotis (*Myotis evotis)* and Pallid Bat (*Antrozous pallidus*) are listed as PS. The Yuma Myotis (*Myotis yumanensis*), Fringed Myotis (*M. thysanoides*), Long-Legged Myotis (*M. volans*), Small-Footed Myotis (*M. leibi*), and Western Pipistrelle (*Pipistrellus hesperus*) are listed as PM. The Townsend's Big-eared Bat (*Plecotus townsendii*) is listed as PT.		
WASHINGTON STATE STATUS OF SPECIAL REPTILE AND AMPHIBIAN SPECIES		
Sagebrush Lizard *Sceloporus graciosus*	PM	Known to inhabit sagebrush-grass habitats
Northern Desert Horned Lizard *Phrynosoma platyrhinos*	PM	Known to inhabit sagebrush-grass habitats
Striped Whipsnake *Masticophis taeniatus*	PM	May be present in sagebrush-grass habitats
Night Snake *Hypsiglena torquata*	PM	May be present in sagebrush-grass habitats
WASHINGTON STATE STATUS OF SPECIAL INVERTEBRATE SPECIES		
Oregon Swallowtail butterfly *Papilio oregonius*	PM	Inhabits sagebrush-grass habitats; ecological status in the vicinity of the 1100 Area is unknown

[a]Definitions of some special classifications of animal species:

State Endangered (SE)--A species that is seriously threatened with extirpation within the State of Washington. These are classified by the State Game Commission as endangered wildlife (WAC 232-12-014). Protected from taking due to damage (RCW 77.1.265).

Proposed Endangered (PE)--A species proposed for consideration for State Endangered classification.

State Threatened (ST)--A species that could become endangered without management or removal of threats. These species are classified by the State Game Commission as protected wildlife (WAC 232-12-011). Protected from possession, control, or destruction of nests or eggs (RCW 77.16.120).

Proposed Threatened (PT)--A species proposed for consideration for State Threatened classification

State Sensitive (SS)--A species that could become Threatened if current water, land, and environmental practices continue. Classified by the State Game Commission as Protected Wildlife and protected from possession, control, or destruction of nests or eggs.

Proposed Sensitive (PS)--A species proposed for consideration for State Sensitive classification.

Monitor Species (SM)--A species of special interest because of public appeal, need for special habitats during a portion of their life cycle, status as indicators of environmental quality, population status that is mostly unknown, taxonomic status in need of further study, or justifiably removed from Endangered, Threatened or Sensitive classifications.

Proposed Monitor (PM)--A species proposed for State Monitor classification.

[b]FE = Federally designated endangered species.
[c]Undetermined.

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APPENDIX B

EXISTING OPERABLE UNIT DATA

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EXISTING OPERABLE UNIT DATA

1.0 INTRODUCTION

Limited data specific to waste disposal operations and groundwater conditions in the 1100-EM-1 operable unit and vicinity are available. Existing data include the following:

- Analyses by the State of Washington of well-head water from the Richland, north Richland, and Duke well fields
- Analyses by Hanford Environmental Health Foundation (HEHF) of well-head water from the north Richland well field
- Analyses of eight preliminary surface soil samples
- Analyses of water samples from 11 wells in the 1100 and 3000 Areas and vicinity
- Analyses of water samples from seven wells in the vicinity of the 1100 Area conducted in August 1988 by the Hanford site-wide groundwater monitoring project.

Results of these analyses will be discussed in terms of water analyses for the north Richland and Duke wells, water analyses for 1100 and 3000 Area groundwater monitoring wells, and analyses of preliminary soil samples.

2.0 WATER ANALYSES FOR THE NORTH RICHLAND AND DUKE WELL FIELDS

The State of Washington Department of Social and Health Services, Division of Health, Public Health Laboratories analyzed a sample from the north Richland well field and one from the Duke well field in January 1988. A total of 54 compounds were analyzed using U.S. Environmental Protection Agency (EPA) Method 524 (EPA 1986a). In the sample from the north Richland well field, the only compounds detected were chloroform, [13.6 parts per billion (p/b)] and bromodichloromethane (1.5 p/b). In the sample from the Duke well field, the only compound detected was chloroform, 1.6 µg/L. Other samples from the Richland water supply system showed similar results. Results of these analyses are available from the city of Richland.

Samples taken in August 1987 from the north Richland well field and analyzed by HEHF show results that are generally consistent with the results obtained by the State of Washington. Well D-5 on the north end of the north Richland well field showed 2.2 µg/L chloroform. No other hydrocarbon compounds out of 36 analyzed were detected above the minimum detection limit of 0.5 µg/L. Well 3000-B showed 1.73 µg/L chloroform, 0.73 µg/L bromoform, and

0.7 μg/L p-chlorotoluene. (The p-chlorotoluene may be an artifact according to the analyst.)

These two samples were also analyzed for a variety of metals and anions important to water quality. The results for constituents above detection levels are as follows. Well D-5: nitrate, 0.32 mg/L; sodium, 2.9 mg/L; chloride, 1.3 mg/L; sulphate, 10.0 mg/L; and total dissolved solids (TDS), 107 mg/L. Well 3000-B: nitrate, 0.67 mg/L; sodium, 2.5 mg/L; chloride, 1.0 mg/L; sulphate, 9.3 mg/L; and TDS, 94 mg/L.

Chloroform, bromoform, and bromodichloromethane are all compounds that can be associated with the chlorination process for city water supplies or with sewage treatment processes. However, these samples were taken at the well head, so these compounds did not result directly from chlorination of Richland city water. Possible explanations of their origin include irrigation of lawns with chlorinated city water and subsequent infiltration of the water into the unconfined aquifer and/or the introduction of chlorinated water to the Yakima and/or Columbia Rivers through irrigation runoff or sewage disposal practices. A one-time sampling of Columbia River water at the 300 Area intake showed none of the chlorination-related compounds.

Similar chlorination-related compounds have been detected in well-head samples from the Vernita rest area, the Wellsian Way well field, and in finished effluent from the Richland sewage treatment plant (37 μg/L). The Vernita rest area is upstream from the Hanford Site approximately 34 mi northwest of the 1100 Area. The Wellsian Way well field is located in the southern part of Richland approximately 4 mi south of the 1100 Area. It is unlikely that either of these areas has been affected by contamination from the 1100 Area, nor is there any indication that the 1100 Area is a potential source of chloroform and related compounds. Therefore, the trace levels of chlorination-related compounds in the north Richland and Duke well fields are not likely to be from the 1100 Area. Instead, the ubiquitous nature of the chlorination-related compounds suggests that they are characteristic of shallow aquifers recharged from the Yakima or Columbia Rivers. Alternatively, they may be the result of irrigation by chlorinated water.

Given the previous discussion, no evidence of contamination of the north Richland and Duke well fields from the 1100-EM-1 operable unit has been detected to date based on direct analysis of the water from the well fields.

3.0 PRELIMINARY SURFACE SOIL SAMPLES

Eight preliminary surface soil samples were taken in March 1988 at the battery acid pit (1100-1), "paint and solvent pit" (1100-2), "antifreeze and degreaser pit" (1100-3), a possible spill located 800 m north of the 1171 Building and west of the shops (the "discolored-soil site"), and from the asphalt emulsion on the large sand hill immediately north of the 1171 Building. Results from these samples are shown in Table B-1.

Table B-1. Analytical Results for Surface Soil Samples from the 1100 Area.

Constituent (µg/g)	Battery acid pit (1100-1) BAP001A01	Battery acid pit (1100-1) BAP001B01	Spill west of tracks SWT001A01	Asphalt emulsion AEP001A01	"Paint and solvent pit" (1100-2) 110002A01	"Paint and solvent pit" (1100-2) 1100002B01	"Antifreeze and degreaser pit" (1100-3) 110003A01	"Antifreeze and degreaser pit" (1100-3) 110003B01
ALPHA (pCi/L)	<1.4	5.3	4.2	3.9	4.3	2.6	<2.2	<0.9
BETA (pCi/L	18.1	20.9	17.3	20.5	16.7	16.8	15.3	14.0
Hg	1.37	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Be	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sr	35	22	18	16	24	21	25	22
Zn	77	58	97	92	46	49	45	47
Ca	11,700	4,520	3,250	4,830	5,130	4,570	9,640	7,530
Ba	91	75	82	57	71	65	72	64
Cd	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cr	12	15	10	9	8	9	7	4
Ag	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Na	849	279	132	047	311	287	253	307
Ni	9	6	9	9	9	9	7	5
Cu	<1.0	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
V	47	58	52	59	58	52	58	60
Sb	<10	<10	<10	<10	<10	<10	<10	<10
Al	1,000	5,710	7,310	5,820	7,710	7,260	6,680	4,970
Mn	276	207	309	270	301	287	290	296
K	1,590	1,230	1,460	786	1,220	1,200	1,300	686
Fe	26,300	25,300	23,800	23,400	25,400	23,700	26,600	28,000
Mg	5,150	4,000	4,790	4,980	5,160	4,990	5,020	4,780
As	4.0	1.2	0.95	1.2	0.9	1.3	0.9	<0.5
Se	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pb	980	1,140	21.4	56.4	20.8	28.4	5.5	4.1
Nitrate	1.6	3.9	<1.0	<1.0	11	5.8	10.5	1.3
Sulfate	1,650	1,510	2.0	3.4	21.2	5.2	5.4	<1.0
Fluoride	2.9	3.9	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloride	1.9	<1.0	<1.0	<1.0	4.3	2.1	1.2	<1.0
Phosphate	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
TOX [a]	<1.0	<1.0	<1.0	4.0	<1.0	<1.0	<1.0	<1.0
TOC [b]	70.3	50.2	353	461	61.5	39.3	45.9	19.0
ETHYGLY [c]	<10	<10	<10	<10	<10	<10	<10	<10
AR1254 [d]	<1.0	1.3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Unknown ABN [e]	ND	1.3	(e)	ND	ND	ND	ND	ND
BISPHT [f]	ND	ND	170	17	ND	ND	ND	ND
DINOPHT [g]	ND	ND	82	ND	ND	ND	ND	ND
Unk. Aliph.HC [h]	ND	ND	ND	(i)	ND	ND	ND	ND

[a]Total organic halogen.
[b]Total organic carbon.
[c]Ethylene glycol.
[d]Arochlor 1254 - polychlorinated biphenyl.
[e]Nine unknown acid-base-neutrals (ABN) with estimated concentrations of 26 to 2,900 µg/g.
[f]Bis(2ethylhexyl) phthalate.
[g]Di-n-octyl phthalate.
[h]Unknown aliphatic hydrocarbon
[i]Nine unknown aliphatic hydrocarbons with estimated concentrations of 22 to 36 µg/L.
ND = not detected.

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These samples were all surface samples intended to give a rapid indication of contamination to assist with development of the work plan. The samples show that the soils at the battery acid pit (1100-1) have elevated levels of lead and sulphate and possibly slightly elevated levels of mercury, chromium, and arsenic. One of the two battery acid pit samples contains measurable quantities of a polychlorinated biphenyl (PCB) (1.3 μg/g).

Samples from the "paint and solvent pit" (1100-2) and the "antifreeze and degreaser pit" (1100-3) did not indicate any evidence of contamination.

The sample from the apparent spill west of the tracks (discolored soil) contains measurable concentrations of two phthalates, nine acid-base-neutral (ABN) organics, and elevated total organic carbon (TOC).

The asphalt emulsion sample was taken to ensure that no hazardous substances were contained in the asphalt emulsion used to stabilize the large dune north of the 1171 Building. The sample contained constituents expected in an asphalt emulsion. No further action is planned for the asphalt emulsion.

4.0 PRELIMINARY WATER ANALYSES FROM 1100 AND 3000 AREA WELLS

Preliminary one-time sampling and water-level measurement of available 1100 and 3000 Area wells was conducted in the summer of 1986 by Pacific Northwest Laboratory (PNL) for the U.S. Department of Energy (DOE). The wells sampled had been drilled for a variety of purposes; some as early as 1943. The wells were not constructed as monitoring wells and have not been routinely sampled as part of the site-wide monitoring project.

The objective of the study was to make an initial assessment of the potentially hazardous constituents that may be present in the groundwater beneath the 1100 and 3000 Areas. Monitoring efforts were concentrated on the areas downgradient from the 1100 Area equipment maintenance facilities (Westinghouse Hanford Company) and the Kaiser Engineers construction facilities. Eleven wells were sampled (see Figure 2-1) between July 18 and 23, 1986. These data are presented in Table B-2. However, the scope of this study was limited, and caution should be exercised when using these data. These data should not be used to determine the water quality in the 1100 and 3000 Areas without additional sampling and research. Limitations noted during the study include the following: completion intervals for several of the wells were not known, three different sampling devices were used, all wells were sampled only once, and results were obtained from two separate analytical laboratories. The analytical results include data obtained by inductively coupled plasma, a method that has been known to yield unreliable results for some metals due to spectral interferences.

Of the 11 wells sampled, one (699-S36-13B) contained a large amount of sediment and yielded anomalous analytical results. The analytical results from this well are listed in Table B-2, but are not considered further and are not included in the generalizations that follow. A second well (ORV),

Table B-2. Analytical Results for Sampled Wells in the 1100 Area - 3000 Area Study (Units in parts per million [p/m]). (Sheet 1 of 2)

Well/Sample / Constituent	3000-G 4903	3000-D 4907	3000-N 4907	699-S31-E13 4902	699-S32-E13A 4906	6-ORV 4898	699-S31-1 4606	6-ATH C 4899	1100-8 4901	3000-D-1 4900D	699-S36-13B 4905
TOX	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
TOC	4.206	5.762	3.748	1.38	1.608	BDL	1.001	2.499	1.278	2.786	9.736
F	<0.1	<0.1	<0.1	<0.1	0.28	1.3	0.94	0.34	0.1	0.16	0.27
Cl	0.85	0.8	1.1	5.5	4.5	2.3	4.8	50	26	6	4.2
NO_3	0.45	0.35	1.5	2.4	21	<0.2	0.2	165	33	12.5	<0.2
SO_4	20.5	9.1	10.0	4.4	20.5	<1	<1	5.9	40	16	13.8
PO_4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ba	0.11	0.1	0.15	0.2	0.47	<0.10	0.21	0.83	0.53	0.23	1.2
Cd	0.010	<0.0005	<0.0005	0.0072	0.0046	<0.0005	0.035	<0.0005	<0.0005	0.012	<0.0005
Mn	<0.1	<0.01	<0.01	1.0	0.16	<0.01	0.055	<0.01	<0.01	0.19	1.63
Na	3.5	3.7	4.1	20	20	42.8	43.7	72	31	17	25.4
K	1.1	0.95	1.82	7.0	9.8	9.6	7.8	13	8.5	5.1	13.2
Fe	<0.03	<0.03	<0.03	32.8	6.7	<0.3	1.67	<0.3	0.068	1.69	16.8
Pb	<0.005	<0.005	<0.005	0.017	0.008	<0.005	0.047	<0.005	<0.005	<0.005	<0.005
Al	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4.9
Cr	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

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Table B-2. Analytical Results for Sampled Wells in the 1100 Area - 3000 Area Study (Units in parts per million [p/m]). (Sheet 2 of 2)

Well/Sample / Constituent	3000-G 4903	3000-D 4907	3000-N 4907	699-S31-E13 4902	699-S32-E13A 4906	6-ORV 4898	699-S31-1 4606	6-ATH C 4899	1100-8 4901	3000-D-1 4900D	699-S36-13B 4905
Ag	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cu	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ni	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
V	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Hg	<0.0005	<0.0005	<0.0005	<0.001[a]	<0.0005	<0.0005	<0.001[a]	<0.0005	<0.0005	<0.0005	<0.0005
ABN	NA	NA	NA	BDL	NA	NA	[b]	NA	NA	NA	NA
VOC	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	[c]	BDL
HERB	NA	NA	NA	BDL	BDL	BDL[d]	BDL	BDL	BDL	BDL	BDL
PEST	NA	NA	NA	BDL	BDL	NA	BDL	NA	NA	BDL	BDL
Coliform	NEG	POS	NEG	NA	NA	NEG	NEG	NEG	NA	NA	NEG

ABN = Acid-base-neutral (semivolatile) organic compounds.
BDL = Below detection limit.
HERB = Herbicides.
NA = Not analyzed.
PEST = Pesticides.
TOC = Total organic carbon.
TOX = Total organic halogen.
VOC = Volatile organic compounds.
[a]Inadequate sample volume for normal detection limit.
[b]bis(2 ethylhexyl) phthalate (code B40) 22 p/b (no other ABNs detected).
[c]Methylene chloride (code A93) 20 p/b (no other VOC detected).
[d]Inadequate sample (detection limit = 0.0016 p/m).

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located at the Off-Road Vehicle Park, includes multiple confined aquifers in its completion interval. Comparison of results from this well with other wells that tap only the unconfined aquifer may not always be appropriate.

Fluoride was detected in 6 of 10 wells, chloride in 10 of 10, nitrate in 8 of 10, and sulphate in 8 of 10. Phosphate was below detection limit [0.5 parts per million (p/m)] for all samples. Chloride was found in higher concentrations (>25 p/m) in the southern part of the study area (1100-D, 26 p/m and athletic complex well, 50 p/m). For the northern part of the study area (ORV, 699-S31-E13, and 699-S32-E13A wells), the range was 2.3 to 5.5 p/m. Concentrations in the 3000 group (3000-G, 3000-D, and 3000-N) ranged from 0.8 to 1.1 p/m, probably reflecting the introduction of Columbia River water to the Richland well field.

Relatively high-nitrate concentrations occur in wells trending from northwest to southeast through the study area (wells 699-S31-1, 3000-D-1, athletic complex, and 1100-D). In these wells, nitrates ranged from 12.5 to 165 p/m. In other wells, the concentrations ranged from <0.02 to 2.4 p/m. The source of the nitrates is unknown, but given the overall easterly flow of groundwater in the area (Newcomb et al. 1972), a single source is unlikely to account for the nitrates in all the wells with elevated concentrations.

Fluoride concentrations in all wells except ORV range from undetectable (<0.1 p/m) to 0.34 p/m. The ORV well had a fluoride concentration of 1.3 p/m. This value is probably explained by the fact that ORV is completed in confined aquifers of the Columbia River Basalt Group, which typically show an increase in fluoride with depth.

Sulphate concentrations vary throughout the study area. Concentrations range from the detection limit (<0.1 p/m) to a high of 40 p/m. No spatial pattern is evident.

Samples were analyzed for volatile organic compounds (VOC), semivolatile (ABN) organic compounds, and/or herbicides and pesticides. Methylene chloride (20 p/b) was found in the groundwater from 3000-D-1 and bis(2-ethylhexyl) phthalate (22 p/b) was present in 699-S31-1. Total organic halogen (TOX) ranged from 0.0002 to 2.8 p/m. Total organic carbon ranged from 1 to 5.8 p/m.

Samples were analyzed for the following metals: barium, cadmium, chromium, silver, copper, mercury, sodium, nickel, manganese, vanadium, aluminum, iron, lead, and potassium. Of these, barium (9 of 10), cadmium (5 of 10), manganese (4 of 10), sodium (10 of 10), potassium (10 of 10), and iron (5 of 10) were present above detection limits. All other metals were below detection limits. Analyses for metals were done by ICP.

Relatively high barium concentrations were located in the same wells that exhibited relatively high nitrate (wells 699-S31-1, 3000-D-1, athletic complex, and 1100-D). For these wells, the barium values ranged from 0.47 to 0.83 p/m. In the remaining wells, barium ranged from undetectable (<0.1 p/m) to 0.23 p/m.

Samples from wells 699-S32-E13A, 3000-D1, and 3000-G had the highest cadmium levels. These wells are located in the northern half of the study area. Values range from undetectable (<0.005 p/m) to a high of 0.035 p/m.

Lead traces were found on the northern perimeter of the study area. Concentrations ranged from undetectable (<0.0005 p/m) to 0.047 p/m. Throughout most of the study area, lead concentrations were at levels too low to detect.

Potassium levels present in all the wells represent background levels for the Hanford Site unconfined aquifer (approximately 5 p/m, [Price et al. 1985]). For wells outside the 3000 group, potassium ranged from 5.1 to 13.2 p/m. Within the 3000 group, the range was 0.9 to 1.82 p/m.

Concentrations of sodium were also significantly lower in the 3000 group wells than in other wells. Values ranged from 3.5 to 4.1 p/m. Sodium in other parts of the area ranged from 17 to 72 p/m. As with several other constituents, this difference stems from the introduction of low TDS Columbia River water into the Richland well field, as well as higher sodium concentrations in the Yakima River compared to the Columbia River (Newcomb et al. 1972).

Along the northern perimeter of the study area, manganese was detected ranging from 0.055 to 1.0 p/m. It was below detection limits in most of the other samples.

Samples for coliform bacteria were drawn from six wells. Well 3000-D tested positive at 2.2 total coliform/100 mL, which is at the detection limit. All other samples tested negative.

Groundwater samples were also collected from seven wells in the vicinity of the 1100 Area during August 1988. The locations of the wells sampled are shown in Figure 2-1. The samples were collected as part of the Hanford sitewide groundwater monitoring project and were analyzed for volatile organic compounds by both PNL and U.S. Testing. Results above detection for volatile organics are presented in Table B-3. The gas chromatography (GC) technique employed by PNL typically yields detection limits 2 to 3 orders of magnitude lower than the GC/mass spectrometry (MS) technique used by U.S. Testing; thus, only two results above detection were reported by U.S. Testing.

Several hazardous constituents found on the lists in Appendix IX, 40 CFR Parts 264 and 270 (EPA 1980 and 1983, respectively) and in WAC 173-303-9905 (Ecology 1987) were detected (Table B-3). In all cases, the concentrations of the hazardous constituents detected were at least 20 times less than levels specified by applicable or relevant and appropriate requirements (see Section 7.0). Two trihalomethanes, chloroform (trichloromethane, $CHCl_3$) and bromodichloromethane, were detected in samples from several wells. Chloroform concentrations ranged from less than detection (0.05 p/b) in well 699-S29-E12 to 1.1 p/b in well 699-S41-13C. Bromodichloromethane was only found in concentrations greater than the detection limit (0.01 p/b) in wells 699-S36-E13A and 699-S41-13C. The maximum contaminant level (MCL) for total trihalomethanes in community water systems that serve a population of 10,000 or more individuals and that add a disinfectant to the water as part of the water treatment process is 100 p/b (40 CFR Part 141 [EPA 1986b]). The

Table B-3. Volatile Organic Compounds Detected in 1100 Area Wells.

Well number	$CHCl_3$ (p/b)[a]	1,1,1-Trichloroethane (p/b)	Trichloroethylene (p/b)	Bromodichloromethane (p/b)	Perchloroethylene (p/b)
699-S29-E12	<0.05	0.06	0.0	<0.01	0.03
699-S29-E12	<0.05	0.06	<0.01	<0.01	0.03
699-S32-E13A	0.37	0.35	0.16	<0.01	0.26
699-S32-E13A	0.37	0.35	0.16	<0.01	0.26
699-S32-E13B	0.50	0.39	0.18	<0.01	0.27
699-S31-1	0.38	0.04	0.02	<0.01	0.02
699-S31-1	0.39	<0.01	<0.01	<0.01	0.01
699-S41-13C	1.11	9.35	0.08	0.05	0.71
699-S41-13C	1.13	10.15	0.10	0.04	0.75
699-S41-13C[b]	<5	8.00	<5	<5	<5
699-S36-E13A	0.83	2.15	0.22	0.01	0.82
699-S36-E13A	0.81	2.19	0.23	0.01	0.84
699-S36-E13A[b]	<5	2	<5	<5	<5
699-S31-E13	0.40	0.40	0.15	<0.01	0.27
699-S31-E13	0.40	0.39	0.15	<0.01	0.27

NOTE: All analyses performed by Pacific Northwest Laboratory using gas chromatography except as noted.
[a]p/b = parts per billion.
[b]Analysis performed by U.S. Testing using gas chromatography/mass spectrometry.

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chlorinated hydrocarbons 1,1,1-trichloroethane (TCA) and trichlorethene (TCE) were also detected in several wells. The highest concentrations of TCA were measured in wells 699-S41-13C and 699-S36-E13A. The MCL for TCA is 200 p/b (40 CFR Parts 141 and 142). Concentrations of TCE less than 1 p/b were detected in most wells sampled. The MCL for TCE is 5 p/b (40 CFR Parts 141 and 142 [EPA 1986b and 1986c, respectively]). Perchloroethene was also detected in concentrations less than 1 p/b in all wells sampled. Perchloroethene is not listed as a hazardous constituent by EPA or Ecology. Carbon tetrachloride was below the detection limits (0.01 p/b) in all samples.

5.0 INITIAL RESULTS FROM FIVE NEW WELLS IN THE 1100 AREA

Five new groundwater monitoring wells were installed in the 1100 Area during October 1988. Water samples were collected on November 7, 1988, and analyzed by both U.S. Testing Company and Pacific Northwest Laboratory. The samples were analyzed for a broad range of constituents including drinking water contaminants, metals, volatile and semivolatile organic compounds, pesticides, herbicides, PCBs, radionuclides, and ethylene glycol. Results of these analyses were reported in Tables B-4, B-5, B-6, and B-7. All concentration levels were found to be well below drinking water standards. The presence of methylene chloride was attributed to sample contamination. This was confirmed by resampling on November 11 and 14, 1988.

Table B-4. Results of Chemical Analyses of Groundwater Samples (collected November 7, 1988 from five new wells in the vicinity of the 1100 Area. Analyses were conducted by U.S. Testing Company). (sheet 1 of 3)

Constituent	Concentration (p/b unless otherwise stated)					
	Well 1 (699-S41-E13A)	Well 2 (699-S40-E14)	Well 3 (699-S41-E13B)	Well 4 (699-S43-E12)	Well 5 (699-S37-E14)	Maximum contaminant level
Nitrate	7.8 p/m	1.0 p/m	4.0 p/m	21.2 p/m	3.0 p/m	10 p/m as nitrogen
Chloride	4.9 p/m	0.9 p/m	8.1 p/m	43.0 p/m	2.1 p/m	250 p/m
Fluoride	<0.5 p/m	<0.5 p/m	<0.5 p/m	<0.5 p/m	<0.5 p/m	1.4 to 2.4 p/m
Sulfate	11.6 p/m	11.9 p/m	11.5 p/m	26.9 p/m	11.5 p/m	250 p/m
Phosphate	<1 p/m	<1 p/m	<1 p/m	<1 p/m	<1 p/m	NR
TOX	<13	44	<8.0	59	61	NR
TOC	<700	<600	<700	1.2 p/m	<600	NR
TC	32.6 p/m	16.9 p/m	47.8 p/m	53.6 p/m	20.2 p/m	NR
pH	7.6	7.6	7.5	7.6	7.8	6.5 to 8.5 pH units
Alkalinity	142 p/m	73 p/m	214 p/m	234 p/m	89.5 p/m	NR
GFAA metals						
Arsenic	<5	<5	<5	<5	<5	50
Selenium	<5	<5	<5	<5	<5	10
Lead	<5	<5	<5	<5	<5	50
Thallium	<5	<5	<5	<5	<5	NR
Mercury	<0.1	<0.1	<0.1	<0.1	<0.1	2
ICP metals						
Zinc	<5	170	65.1	59.2	<5	5,000
Calcium	39.1 p/m	23.3 p/m	57.9 p/m	88.1 p/m	28.1 p/m	NR
Barium	32.9	15.9	57.9	58.6	18.7	1,000
Cadmium	<2	<2	<2	<2	<2	10
Chromium	<10	<10	<10	<10	<10	50
Silver	<10	<10	<10	<10	<10	50
Sodium	7.76 p/m	2.43 p/m	16.60 p/m	24.70 p/m	4.50 p/m	NR

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Table B-4. Results of Chemical Analyses of Groundwater Samples (collected November 7, 1988, from five new wells in the vicinity of the 1100 Area. Analyses were conducted by U.S. Testing Company). (sheet 2 of 3)

Constituent	Concentration (p/b unless otherwise stated)					
	Well 1 (699-S41-E13A)	Well 2 (699-S40-E14)	Well 3 (699-S41-E13B)	Well 4 (699-S43-E12)	Well 5 (699-S37-E14)	Maximum contaminant level
ICP metals (cont.)						
Nickel	<10	<10	<10	<10	<10	NR
Copper	<10	<10	<10	<10	<10	1,000
Vanadium	6.33	<5	<5	7.51	5.97	NR
Aluminum	<150	<150	<150	<150	<150	NR
Manganese	57.1	5.6	176	70.3	6.3	50
Potassium	4.81 p/m	1.18 p/m	5.86 p/m	8.37 p/m	2.29 p/m	NR
Iron	<30	<30	36	34.3	<30	300
Magnesium	8.3 p/m	4.6 p/m	12.2 p/m	16.4 p/m	5.1 p/m	NR
Beryllium	<5	<5	<5	<5	<5	NR
Strontium	175	104	264	368	106	NR
Antimony	<100	<100	<100	<100	<100	NR
Pesticides						
Endrin	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Methoxychlor	<3	<3	<3	<3	<3	100
Toxaphene	<1.0	<1.0	<1.0	<1.0	<1.0	5
Alpha BHC	<0.1	<0.1	<0.1	<0.1	<0.1	5
Beta BHC	<0.1	<0.1	<0.1	<0.1	<0.1	5
Gamma BHC	<0.1	<0.1	<0.1	<0.1	<0.1	5
Delta BHC	<0.1	<0.1	<0.1	<0.1	<0.1	5
VOC						
Carbon tetrachloride	<5	<5	<5	<5	<5	5
Methone[a]	<10	<10	<10	<10	<10	NR
1, 1, 1 - T[b]	<5	<5	<5	<5	<5	200
1, 1, 2 - T[c]	<5	<5	<5	<5	<5	NR
TCE	<5	<5	<5	<5	<5	5

Table B-4. Results of Chemical Analyses of Groundwater Samples (collected November 7, 1988, from five new wells in the vicinity of the 1100 Area. Analyses were conducted by U.S. Testing Company). (sheet 3 of 3)

Constituent	Concentration (p/b unless otherwise stated)					
	Well 1 (699-S41-E13A)	Well 2 (699-S40-E14)	Well 3 (699-S41-E13B)	Well 4 (699-S43-E12)	Well 5 (699-S37-E14)	Maximum contaminant level
VOC (cont.)						
PCE	<5	<5	<5	<5	<5	NR
Opxylen[d]	<5	<5	<5	<5	<5	NR
Chloroform	<5	<5	<5	<5	<4	100[e]
Methylene chloride	12[f]	72[f]	<10	78[f]	<10	NR
M-xyle[g]	<5	<5	<5	<5	<5	NR
Hexone[h]	<10	<10	<10	<10	<10	NR
Herbicides	<2.0	<2.0	<2.0	<2.0	<2.0	10 to 100
Ethylene glycol	<10 p/m	<10 p/m	<10 p/m	<10 p/m	<10 p/m	NR
PCB	<1.0	<1.0	<1.0	<1.0	<1.0	NR
ABN	<detect	<detect	<detect	<detect	<detect	--

ABN = Acid-base neutral; semivolatile organic constituents having varying detection limits.
BHC = Benzene hexachloride.
GFAA = Graphite furnace atomic absorption.
ICP = Inductively coupled plasma.
M-xyle = Meta xylene.
NR = Not regulated in groundwater, no maximum contaminant level or regulatory limit has been established.
PCB = Polychlorinated biphenyl.
PCE = Perchloroethene.
TC = Trichloroacetic acid.
TCE = Trichloroethylene.
TOC = Total organic carbon.
TOX = Total organic halogen.
VOC = Volatile organic compound.

[a]Methone = Methylethyl ketone.

[b]1, 1, 1 - T = 1, 1, 1 trichloroethane.

[c]1, 1, 2 - T = 1, 1, 2 trichloroethane.

[d]Opxylen = Ortha para xylene.

[e]Total trihalomethane must be less than 100 p/b.

[f]Methylene chloride below detection level for samples collected November 11 and 14, 1988, and analyzed by Pacific Northwest Laboratory, indicating that samples collected November 7, 1988, and analyzed by U.S. Testing Company and Pacific Northwest Laboratory were contaminated with methylene chloride during sample collection process.

[g]M-xyle = Meta xylene.

[h]Hexone = Methyl isobutyl ketone.

Table B-5. Results of Volatile Organic Analyses of Groundwater Samples Collected November 7, 1988 (from five new wells in the vicinity of the 1100 Area. Analyses were conducted by Pacific Northwest Laboratory).

Constituent	Concentration (p/b unless otherwise stated)					
	Well 1 (699-S41-E13A)	Well 2 (699-S40-E14)	Well 3 (699-S41-E13B)	Well 4 (699-S43-E12)	Well 5 (699-S37-E14)	Maximum contaminant level
VOC						
Methylene chloride	7 (<3)[a]	44 (<3)[a]	<3	48 (<3)[a]	<3	NR
Chloroform	0.30	0.25	0.57	0.28	4.2	100[b]
1, 1, 1 - T[c]	0.03	<0.02	0.02	0.04	0.31	200
Carbon tetrachloride	<0.01	<0.01	<0.01	<0.01	<0.01	5
TCE	0.02	<0.02	0.09	0.11	0.07	5
BDCM	<0.01	<0.01	<0.01	<0.01	0.01	100[b]
PCE	0.11	<0.01	0.20	0.02	0.12	NR

NR = Not regulated in groundwater, no maximum contaminant level or regulatory limit has been established.
BDCM = Bromodichloromethane.
PCE = Perchloroethene.
TCE = Trichloroethylene.

[a]Methylene chloride below detection level for samples collected November 11 and 14, 1988, and analyzed by Pacific Northwest Laboratory indicating that samples collected November 7, 1988, and analyzed by U.S. Testing Company and Pacific Northwest Laboratory were contaminated with methylene chloride during sample collection process.

[b]Total trihalomethane must be less than 100 p/b.

[c]1, 1, 1 - T = 1, 1, 1 trichloroethane.

Table B-6. Results of Volatile Organic Analyses of Groundwater Samples Collected November 11, and 14, 1988 (from five new wells in the vicinity of the 1100 Area. Analyses were conducted by Pacific Northwest Laboratory).

Constituent	Concentration (p/b unless otherwise stated)					
	Well 1 (699-S41-E13A)	Well 2 (699-S40-E14)	Well 3 (699-S41-E13B)	Well 4 (699-S43-E12)	Well 5 (699-S37-E14)	Maximum contaminant level
VOC						
Methylene chloride	<3	<3	<3	<3	<3	NR
Chloroform	0.29	0.57	0.56	0.31	5.3	100[a]
1, 1, 1 - T[b]	<0.02	<0.02	0.03	0.02	0.35	200
Carbon tetrachloride	<0.01	<0.01	<0.01	<0.01	<0.01	5
TCE	0.03	<0.02	0.10	0.14	0.08	5
BDCM	<0.01	0.03	<0.01	<0.01	0.15	100[b]
PCE	0.12	<0.01	0.22	0.02	0.13	NR

NR = Not regulated in groundwater, no maximum contaminant level or regulatory limit has been established.
BDCM = Bromodichloromethane.
PCE = Perchloroethene.
TCE = Trichloroethylene.
[a]Total trihalomethane must be less than 100 p/b.
[b]1, 1, 1 - T = 1, 1, 1 trichloroethane.

Table B-7. Results of Radiological Analyses of Groundwater Samples (collected November 7, 1988, from five new wells in the vicinity of the 100 Area. Analyses were conducted by U.S. Testing Company. Analytical result and (±) overall error are reported.)

Constituent	Concentration (pCi/L)					
	Well 1 (699-S41-E13A)	Well 2 (699-S40-E14)	Well 3 (699-S41-E13B)	Well 4 (699-S43-E12)	Well 5 (699-S37-E14)	Maximum contaminant level
Alpha	8.2 ± 2.42	1.27 ± 0.92	6.57 ± 2.34	8.61 ± 3.79	1.91 ± 1.18	15
Beta	15.5 ± 6.23	1.32 ± 2.96	11.3 ± 4.84	10.6 ± 5.45	3.59 ± 3.56	4 millirem/yr
Uranium	2.24 ± 0.76	0.57 ± 0.26	2.13 ± 0.70	3.76 ± 1.16	0.39 ± 0.21	NR
Tritium	32.2 ± 329	61.1 ± 334	126 ± 338	168 ± 340	232 ± 343	20,000

NR = Not regulated in groundwater, no maximum contaminant level or regulatory limit has been established.

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APPENDIX C

ENVIRONMENTAL INVESTIGATIONS AND INSTRUCTIONS

APPENDIX C

ENVIRONMENTAL INVESTIGATION INSTRUCTIONS (EII).

Number	Procedure title/topic	Anticipated issue date
EII 1.2	Preparation and revision of environmental investigation instructions	Completed
EII 1.4	Deviation from environmental investigation instructions	Completed
EII 1.5	Field logbooks	Completed
EII 1.6	Records management	Completed
EII 1.7	Indoctrination, training, and qualification	Completed
EII 2.1	Preparation of health and safety plans	Completed
EII 2.2	Dosimetry	Completed
EII 3.1	User calibration of measurement and test equipment (health/safety)	Completed
EII 5.1	Chain of custody	Completed
EII 5.2	Soil and sediment sampling	Completed
EII 5.3	Biotic sampling	Completed
EII 5.4	Field decontamination of drilling equipment	Completed
EII 5.5	Decontamination of equipment for RCRA/CERCLA sampling	Completed
EII 5.6	Control of geophysical logging	Completed
EII 5.7	Hanford geotechnical library control (sample archiving)	Completed
EII 6.1	Activity reports of field operations	Completed
EII 6.2	Groundwater monitoring well technical oversight	Completed
EII 6.3	Preparation of groundwater monitoring well construction specifications	Completed
EII 6.4	Groundwater monitoring well maintenance	June 1989
EII 9.1	Geologic logging	Completed
EII 10.1	Aquifer testing	Completed
EII 10.2	Measurement of groundwater level s	Completed
EII 10.3	Disposal of well construction/development waters (purgewater disposal)	In preparation

APPENDIX D

COMPARISON OF AVAILABLE CODES FOR REMEDIAL INVESTIGATION/FEASIBILITY STUDY

APPENDIX D

COMPARISON OF AVAILABLE CODES FOR REMEDIAL INVESTIGATION/FEASIBILITY STUDY

1.0 PURPOSE

Computer models and codes provide a framework to incorporate the processes that are active at a waste disposal site, thereby permitting assessment and evaluation of various waste management options for a given site. The time frames, ranging from decades to thousands of years, associated with evaluation of waste isolation potential for a given site also necessitate the use of models and codes.

Because of the importance of the computer models relative to the performance assessment and risk assessment of a waste disposal site, a process to compare these codes has been developed. The codes must be compared to determine the limitations of theories and reliability of supporting empirical relations and laboratory tests used for evaluation of long-term waste isolation potential.

The purpose of this section is to provide a comparison of a variety of codes that are possible candidates for use in the remedial investigation/feasibility study (RI/FS) of a given site. The groundwater, air, biotic, direct contact, and surface-water pathways are considered for transport of contaminants. Such a comparison can be used to function in the following manners:

- Provide a screening mechanism (i.e., to determine which codes are applicable to a specific requirement at a given site)
- Indicate potential deficiencies of the codes
- Evaluate the necessity of additional codes that do not currently exist but might be required in the future for an RI/FS
- Provide a basis for gathering additional field data during site characterization.

2.0 SCOPE OF WORK

The codes compared in this report were selected as part of a two-step process. The first step in comparing the codes was to assemble the list of relevant codes that can potentially be used in an RI/FS. The second step was to prepare a table describing the important features of selected codes. As part of the second step, a detailed comparison of the selected codes was performed and a comparison table was developed.

The criteria used in assembling the list of codes may be summarized as follows.

- Codes developed and used by the U.S. Department of Energy (DOE), U.S. Nuclear Regulatory Commission (NRC), and U.S. Environmental Protection Agency (EPA) should be selected.
- These codes should be:
  - Unclassified
  - Off-the-shelf
  - Documented sufficiently to make preparation of an evaluation feasible.
- If codes are available in several versions, the most recent should be used.
- The total number of codes reviewed must be consistent with schedule and manhours available.

Furthermore, the comparison process should address the following:

- Stage of development of the code
- Verification and benchmark status
- Validation status
- Availability of users' manual
- Acceptance by regulatory agencies (i.e., code usage by the DOE, NRC, and EPA)
- Acceptance by the scientific community (i.e., availability of peer-reviewed journal articles incorporating code description and verification and benchmark results)
- Operational readiness status of the code at the Hanford Site
- Cost of using the code
- Strengths of the code
- Limitations
- Input data required
- Availability of preprocessors and postprocessors for a code
- Ability (or inability) to model Hanford Site conditions; in particular, ability to model the dry, heterogeneous vadose zone soils at the Hanford Site
- Hardware requirements for a code

- Expertise required to use a code
- Marginal advantage of one code over another.

The comparisons are based on available publications and documentation of the codes, supplemented in some cases by the experience of members of the Environmental Technology Group. The comparisons are not comprehensive; rather, the goal was to indicate how the codes might be used in RI/FS analysis and point out the deficiencies in the codes. These comparisons, therefore, represent a first step in the screening process for using a code for a given site.

Table D-1 provides a comparison table for integrated transport codes. Table D-2 describes several groundwater pathway codes. Table D-3 describes transport codes for the air, biotic, and direct-contact pathways.

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Table D-1. Integrated Models for All Pathways. (sheet 1 of 2)

Computer code name	Stage of development	Verification/ benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/ another
RAPS/ MEPAS (model to simulate contaminant transport from a waste disposal site and to evaluate human exposure)	Fully developed	Verified and benchmarked (Whelan et al. 1987)	Not validated	Yes (Whelan et al. 1986)	U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA)	Unknown	Available on site Pacific Northwest Laboratory (PNL)	Low	Minimum knowledge of risk assessment and a minimum amount of input data; considers groundwater, overland, surface water, and atmospheric pathways	Can be used to rank or prioritize sites; but cannot be used in a predictive mode to simulate actual risks at a particular site from the release of contaminants	Dispersion coefficients, hydraulic conductivities, degradation rates, modes of exposure, and dose response information	No	Unknown	Micro/minicomputer	Familiarity with users' manual	Can be applied to rank or prioritize sites; includes simplified models for risk assessments to important receptors
PATHRAE (simulates transport from groundwater, surface water, atmospheric, and occupational pathways)	Fully developed	Unknown	Not validated	Yes (Rogers and Hung, 1987)	DOE/U.S. Nuclear Regulatory Commission (NRC)	Unknown	Available on site (PNL)	Low	Minimum user knowledge of risk assessment and a minimum amount of input data; considers complex processes migration, degradation, transformation, transfer between media (air, water, etc.) and biological uptake	Can be used to rank or prioritize sites, but cannot be used in a predictive mode to simulate actual risks at a particular site from the release of contaminants	Dispersion coefficients, hydraulic conductivities, degradation rates, modes of exposure, and dose response information	No	Unknown	Micro/minicomputer	Familiarity with users' manual	Can be applied to rank or prioritize sites; includes simplified models for risk assessments to important receptors

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Table D-2. Integrated Models for All Pathways. (sheet 2 of 2)

Computer code name	Stage of development	Verification/ benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/ another
GEMS (EPA library of codes to model each potential transport pathway)	Fully developed	Unknown	Unknown	Yes (GSC 1982)	EPA	Unknown	Not currently available on site	Medium to high	Unknown	Unknown	Dispersion coefficients, hydraulic, conductivities, degradation rates, modes of exposure, and dose response information	Yes	Unknown	Terminal and modem to access GEMS	Limited modeling experience and familiarity with users' manual	EPA model

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Table D-2. Available Groundwater Pathway Computer Codes for Remedial Investigation/ Feasibility Study. (Sheet 1 of 4)

Computer code name	Stage of development	Verification/ benchmarking status	Validation status	Users' manual available ?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/ another
CHAINT (2D transport code for saturated and unsaturated media; includes radionuclide decay and adsorption for contaminants)	Fully developed	Partially verified and benchmarked	Not validated	Yes	DOE	Unknown	Available on PRIME 750	Medium	Low cost for vadose zone flow simulation, two-dimensional transport	One-dimensional, vertical, steady-state unit gradient model for vadose zone, does not allow for source/sink terms	Soil moisture characteristics for various layers	Yes	Applied to 200 Areas solid waste disposal sites	Mini/ mainframe computers	Familiarity with users' manual, theory description	Low cost of simulation, Westinghouse Hanford Company personnel familiarity with codes, less data requirements
MAGNUM (2D code for simulated groundwater flow in saturated aquifers)	Fully developed	Verified and benchmarked	Not validated	Yes	DOE	Unknown	Available on PRIME 750	Medium	Two-dimensional flow simulations	Does not allow for source/sink terms within aquifers	Hydraulic characteristics for various zones with aquifers	Yes	Extensively applied to Hanford Site basalt aquifers (flow tops and dense interiors)	Mini/ mainframe computers	Familiarity with users' manual, theory description	Low cost of simulation, Westinghouse Hanford Company personnel familiarity with code. MAGNUM was especially developed for modeling flow in basalt environment
FEMWATER/ FEMWASTE	Fully developed	Verified and benchmarked (Yeh et al. 1987)	Not validated	Yes	DOE		Not available on site	High	Two-dimensional flow and transport includes sources/ sinks	Long execution times, inability to model heterogeneous vadose zone soils	Moisture characteristic curves for various vadose zone layers	No	Unknown	Mini/ mainframe computers	High degree of familiarity with theory and users' manuals	Integrated saturated/ unsaturated zone modeling flow including sources/ sinks for unconfined aquifer

PST88-3340-E2

Table D-2. Available Groundwater Pathway Computer Codes for Remedial Investigation/ Feasibility Study. (Sheet 2 of 4)

Computer code name	Stage of development	Verification/ benchmarking status	Validation status	Users' manual available ?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/ another
VAM2D/ SATURN (2D flow and transport code for saturated/ unsaturated media; includes decay and adsorption)	Fully developed	Verified and benchmarked (Huyakorn et al. 1984)	Not validated	Yes	U.S. Department of Energy (DOE) U.S. Nuclear Regulatory Commission (NRC)	Huyakorn et al. 1984, 1985, 1987		Medium	Includes a simplified option for modeling vadose zone; includes option sources/ sinks for aquifers	Long execution times, for the full saturated/ unsaturated flow and transport modeling	Hydraulic characteristics for various vadose zone layers and unconfined aquifers	No	Capable of modeling heterogeneous layered media (such as those existing at Hanford Site)	Mini/ mainframe computers	High degree of familiarity with theory and users' manuals	Simplified option for vadose zone modeling; option for including sources/sinks for unconfined aquifer; integrated modeling of saturated/ unsaturated media
TRACR3D (3D code for modeling flow and transport of multiphase organics in vadose zone)	Fully developed	Currently being verified and benchmarked at Pacific Northwest Laboratory (PNL) for the Hanford Site grout program	Not validated	Yes, (Travis 1984)	DOE, NRC	Unknown	Available at PNL	High	Multi-dimensional modeling of flow and transport of organics	Does not include flow and transport in unconfined aquifer; limited ability to model heterogeneous vadose zone properties	Relative permeability versus saturation relationships for various multiphase organics	No	Has difficulty in simulating flow through heterogeneous layered media (such as those existing at Hanford Site)	Mini/ mainframe computers	High degree of familiarity with theory and users' manuals	Ability to model multi-dimensional, multiphase flow and transport in vadose zone
PORFLO (3D code for simulating flow, heat transport and mass transport saturated porous media)	Fully developed	(Eyler and Budden 1984)	Not validated	Yes, (Kline et al. 1983)	DOE	Unknown	Available onsite	Medium	Three-dimensional simulations possible; allows for sources/ sinks in unconfined aquifers	Vadose zone simulation capabilities not available but are currently being incorporated	Hydraulic properties of various heterogeneities in the saturated aquifer	Yes	Extensively applied to model flow and transport through Hanford Site basalts	Mini/ mainframe computers	High degree of familiarity with theory and users' manuals	Ability to model three-dimensional flow and transport in saturated media, Westinghouse Hanford Company familiarity with code
MODFLO (3D code for simulating flow in saturated porous media)	Fully developed	(McDonald and Harbaugh 1984)	Not validated	Yes	U.S. Geological Survey	Unknown	Not available onsite	Medium	Modular structure of various submodels	Vadose zone simulation capabilities not available	Hydraulic properties of saturated confined and unconfined aquifers	No	Unknown	Mini/ mainframe computers	Familiarity with users' manual	Ability to model three-dimensional flow in saturated media

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Table D-2. Available Groundwater Pathway Computer Codes for Remedial Investigation/ Feasibility Study. (Sheet 3 of 4)

Computer code name	Stage of develop-ment	Verification/ benchmark-ing status	Validation status	Users' manual available ?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware require-ments	Expertise required	Marginal advantage of one model/ another
VAM3D (3D flow and transport code for modeling flow and transport through saturated/ unsaturated media; includes decay and adsorption)	Fully developed	Verified and bench-marked (Huyakorn et al. 1985)	Not validated	Yes	DOE	Unknown	Not avail-able on site	Verify high	Includes a simplified option for modeling vadose zone; includes option for incorpor-ating source/ sink terms in aquifers	Very long execution times for modeling the full, 3D, saturated/ unsaturated media	Hydraulic properties for various vadose zone layers and unconfined aquifers	No	Capable of modeling hetero-geneous layered media (such as those existing at Hanford Site)	Mainframe computer	Very high degree of familiarity with theory and users manuals	Ability to the fill, 3D flow and transport in an inte-grated saturated/ unsaturated media, with sources/ sinks in unconfined aquifers
UNSAT2	Fully developed	Verified and bench-marked	Not validated	Yes	DOE/NRC	(Neuman 1973)	Available at PNL	Medium	Two-dimen-sional vadose zone and uncon-fined aquifer simulations with sources/ sinks present in unconfined aquifer	Vadose zone flow simula-tion capabil-ities limited to simpler, smaller flow domains; does not include con-taminant transport modeling option	Hydraulic properties for various vadose zone layers and unconfined aquifers	No	Has diffi-culty in simulating flow through hetero-geneous, layered media (such as those existing at Hanford Site)	Mini/ mainframe computer	High degree of familiarity with theory and users manuals	Ability to model 2D in integrated saturated/ unsaturated media, with sources/ sinks in unconfined aquifers
UNSAT-H (1D model for simu-lating flow through vadose zone)	Fully developed	Verified and bench-marked	Not validated	Yes	DOE	Unknown	Available at PNL	Low	Developed specifically for Hanford Site condi-tions; includes a water balance subroutine	One-dimen-sional model, limited applicability to multi-dimensional, heterogen-eous layered media	Soil proper-ties, plant data for ET calculations	Unknown	Capable of simulating flow in heterogen-eous layered media	Mini/ mainframe computer	Familiarity with users manual	Has been applied to Hanford Site conditions

PST88-3348-E2

Table D-2. Available Groundwater Pathway Computer Codes for Remedial Investigation/ Feasibility Study. (Sheet 4 of 4)

Computer code name	Stage of development	Verification/ benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/ another
RITZ (simulates movement fate of hazardous chemicals during land treatment of oily wastes)	Fully developed	Unknown	Not validated	Yes, (Nofziger and Williams 1988)	U.S. Environmental Protection Agengy (EPA)	Unknown	Available onsite	Low	Simple model with few data requirements; can be applied in case of organics	Assumptions are highly simplistic and may not be valid in nature; cannot be used to simulate actual risks at a site	Input data on soil, pollutant, oil, environmental, and operational parameters for land treatment sites	Yes	Unknown	Microcomputer	Familiarity with users' manual	Can be applied to obtain preliminary data on transport and fate of organics in the vadose zone
SESOIL (unsaturated zone transport model)	Fully developed	Unknown	Not validated	Yes, (Bonazountas and Wagner, 1981)	EPA	Unknown	Available through GEMS	Low - Medium	Models organic and inorganic species; accounts for adsorption, volatilization, degradation, and biodegradation	Only handles up to three soil layers	Hydrologic and meteorologic data, contaminant information	Yes	Unknown	Terminal and modem access to GEMS	Familiarity with users' manual	Versatile, easy to use, EPA acceptance
HELP (1-D unsaturated flow and transport model)	Fully developed	Unknown	Not validated		EPA	Unknown	Available onsite	Low	Simple model for rough calculations, models organic and inorganic species	Simple 1-D approach may not be adequate at some sites	Hydrologic and meteorologic data, contaminant information	No	Yes	IBM-PC or equivalent	Familiarity with users' manual	Easy to use, EPA acceptance

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Table D-3. Models for Air, Biotic, Direct Contact, and Surface Water Pathways. (Sheet 1 of 3)

Computer code name	Stage of develop-ment	Verification/ benchmark-ing status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware require-ments	Expertise required	Marginal advantage of one model/ another
AIR PATH-WAY																
TOXBOX (basic box model)	Fully developed	Unknown	Unknown	(GSC 1982)	U.S. Environmental Protection Agency (EPA)	Unknown	Not cur-rently acces-sible at Hanford Site	Low-Medium	Can represent vertical disper-sion; areal source; available through GEMS	Simplified box model	Unknown	Yes	No site-specific limitations	Terminal and modem to access GEMS	Limited modeling experience	Ease of use and EPA acceptance
INDUSTRIAL SOURCE COMPLEX (Gaussian dispersion model)	Fully developed	Unknown	Unknown	(GSC 1982)	EPA	Unknown	Not cur-rently acces-sible at Hanford Site	Low-Medium	Long- and short term simula-tions; settling and dry deposition of particles; multiple point sources; limited terrain adjust-ments	Unknown	Meteorolog-ical and source data	Yes	No site-specific limitations	Terminal and modem to access GEMS; mini/ mainframe computer	Limited modeling experience	Rigorous approach and EPA acceptance
SEE ALSO PATHRAE AND RAPS/ MEPAS																

PST88-3340-E3

Table D-3. Models for Air, Biotic, Direct Contact, and Surface Water Pathways. (Sheet 2 of 3)

Computer code name	Stage of develop-ment	Verification/ benchmark-ing status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware require-ments	Expertise required	Marginal advantage of one model/ another
BIOTIC PATHWAY																
BIOPORT/ MAXI 1 (Radiation dose due to plants and animals	Fully developed	Planned for FY 1989	Planned for FY 1989	(McKenzie et al. 1985)	NRC	Unknown	Available at Hanford Site	Low	Radiation dose calcu-lated for ingestion, inhalation, and direct exposure; intrusion and active physical transport are considered	Does not consider hazardous chemicals	Agricultural and water-usage practices; wildlife information	No	No site-specific limitations	Mini/ mainframe computer	Limited modeling experience	Developed at Hanford Site
SEE ALSO PATHRAE AND RAPS/ MEPAS																
DIRECT-CONTACT PATHWAY																
ONSITE/ MAXI 1 (Radiation dose due to direct intrusion)	Fully developed	Unknown	Unknown	(Kennedy et al. 1986, 1987)	NRC	Unknown	Available at Hanford Site	Low	Radiation dose calculated for direct exposure and ingestion (food and water)	Does not consider hazardous chemicals	Agricultural and water-usage practices; lifestyle characteris-tics of intruder/ resident	No	No site-specific limitations	Micro/mini/ mainframe computer	Limited modeling experience	Developed at Hanford Site
SEE ALSO PATHRAE AND RAPS/ MEPAS																

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Table D-3. Models for Air, Biotic, Direct Contact, and Surface Water Pathways. (Sheet 3 of 3)

Computer code name	Stage of development	Verification/ benchmarking status	Validation status	Users' manual available?	Acceptance by regulatory agencies	Acceptance by scientific community	Operational readiness	Cost of utilization	Strengths	Limitations	Input data required	Pre/post processors available?	Ability to model Hanford Site conditions	Hardware requirements	Expertise required	Marginal advantage of one model/ another
SURFACE WATER PATHWAY																
EXPOSURE ANALYSIS MODELING SYSTEM (3-D compartmental model for freshwater, nontidal systems)	Fully developed	Unknown	Unknown	(Burns et al. 1982) (GSD 1982)	EPA	Unknown	Not currently accessible at Hanford	Medium-High		Unknown	Unknown	Yes	No site-specific requirements	Mini/ mainframe computer	Understanding of transport process and modeling experience	Rigorous approach and EPA acceptance
WATER QUALITY ASSESSMENT METHODOLOGY (1-D Model for lakes, rivers, and streams)	Fully developed	Unknown	Unknown	(Mills et al. 1982)	EPA	Unknown	Not currently accessible at Hanford	Low	Easy to use with desk calculator	Very simple approach	Limited data requirements	No	No site-specific requirements	Calculator	Limited modeling experience	Ease of use and EPA acceptance
SEE ALSO RAPS/ MEPAS AND PATHRAE																

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Mills, W. B., J. D. Dean, and D. B. Porcella, 1982, *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants, Parts 1, 2, and 3*, EPA 600 6-82-004, U.S. Environmental Protection Agency, Athens, Georgia.

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APPENDIX E

PHASE 2 REMEDIAL INVESTIGATION--TREATABILITY INVESTIGATION

APPENDIX E

PHASE 2 REMEDIAL INVESTIGATION--TREATABILITY INVESTIGATION

As operable unit information is collected during the Phase 2 remedial investigation (RI), and alternatives are being developed and screened during the first and second phases of the feasibility study (FS), additional data needs necessary to adequately evaluate alternatives during the detailed analysis may be identified. Activities may include the collection of additional data necessary for operable unit characterization or the conduct of treatability investigations to better evaluate the performance of certain remedial technologies.

Some of the technologies selected for detailed analysis at the 1100-EM-1 operable unit may be well developed, proven, and documented such that unit-specific information collected during the RI is adequate for evaluation without conducting treatability testing. However, some technologies may not be sufficiently demonstrated to predict treatment performance or to estimate the size and cost of treatment units. Some treatment processes, particularly innovative technologies, are not sufficiently understood for performance to be predicted, even with a complete characterization of the wastes. When treatment performance is difficult to predict, actual testing of the process, on either a bench scale or pilot scale, may provide the most cost-effective means of obtaining the necessary performance data. At the Hanford Site, some treatability investigations may be performed on a site-wide basis rather than on a unit-specific basis. Any such site-wide treatability investigation results relevant to the 1100-EM-1 operable unit that are completed in time to be applied to the operable unit will be incorporated into the project through the normal FS technology performance evaluation process.

The primary purpose of the treatability investigation, in accordance with draft U.S. Environmental Protection Agency (EPA) RI/FS guidance (EPA 1988), is to provide sufficient technology performance information and reduce cost and performance uncertainties to acceptable levels such that treatment alternatives can be fully developed and evaluated during the Phase 3 FS. Secondarily, the treatability investigation may generate information useful in conducting the detailed design of a treatment remedy, if such a remedy is selected for the operable unit. In addition, the allocation of time for a potential treatability investigation provides a mechanism through which to conduct further operable unit characterization activities in the event that the need for such activities is identified at or toward the end of the Phase 1 RI.

The need for any treatment investigation or additional characterization of the operable unit will be apparent once the Phase 2 FS is completed. If and when the need arises to implement a treatability investigation, this portion of the work plan will be expanded by amendment to provide such details of the Phase 2 RI activities. If the need for further operable unit characterization is identified after, or toward the end of, the Phase 1 RI, the Phase 2 RI will also focus on obtaining any additional information needed to support the Phase 3 FS. The accompanying volumes of the RI/FS project plans, and pertinent portions of this work plan, will also be amended, as appropriate, to provide guidance for the required work prior to implementation. The Phase 1 RI, Phase 1 FS (interim), and Phase 1/2 FS reports will provide formal, interim evaluations of further data needs, in terms of both treatability investigation and operable unit characterization, for the Phase 2 RI.

1.0 TREATABILITY INVESTIGATION WORK PLAN DEVELOPMENT

Treatability testing to support the Phase 3 FS can be performed by using either bench-scale or pilot-scale studies. A work plan for such studies will be developed, as appropriate. If necessary, a literature survey, supplementing those conducted during the initial phases of the FS, will be conducted to identify specific data needs for the treatability investigation. The objectives of such a survey are to do the following.

- Determine whether the performances of treatment technologies under consideration have been sufficiently documented on similar wastes, taking into consideration the scale of such documentation (e.g., bench, pilot, or full scale).
- Determine the number of times the treatment technologies have been successfully used.
- Gather information on relative costs, applicability, removal efficiencies, operations and maintenance requirements, and implementability of the candidate treatment technologies.
- Determine specific testing requirements and appropriate scale for any required treatability tests.

Any treatability studies will include the following steps:

- Preparation, review, and approval of a treatability investigation work plan for the bench-scale or pilot-scale studies
- Performance of the bench-scale or pilot-scale testing
- Evaluation of data from bench-scale or pilot-scale testing
- Incorporation of the results of the testing into the final RI report.

Bench-scale (laboratory) testing may be used to provide information to determine the feasibility of waste treatment or destruction technologies, although care must be taken in extrapolating laboratory data to full-scale performance. Bench-scale tests can be used to evaluate a wide variety of operating conditions and to determine broad operating conditions to allow optimization during additional bench- or pilot-scale tests. Bench-scale testing is usually a fast and low-cost process, relative to pilot-scale testing.

Potential objectives of bench-scale testing are to determine the following:

- The effectiveness of the treatment technology on the operable unit wastes
- The differences in performance between competing manufacturers
- The differences in performance between alternative chemicals used in the treatment process
- The sizing requirements for any pilot-scale studies
- Screening of potential technologies to be pilot tested
- Sizing of those treatment units that would affect the cost of the technology sufficiently to affect the remedial alternatives analysis process (Phase 3 FS)
- Compatibility of process materials with the operable unit wastes.

Prior to initiating bench-scale treatability tests, the following information will be collected or developed:

- Test procedures
- A waste sampling plan
- Waste characterization (will be available from Phase 1 RI data)
- Treatment goals (will be available, or can be derived, from remedial action objectives defined and refined during the initial phases of the FS)
- Data requirements for estimating the technology cost within -30 to +50 percent accuracy
- Required test services, equipment, chemicals, and analytical services.

For a technology that is well developed and tested, bench-scale studies are usually sufficient to evaluate performance on new wastes. For innovative technologies, however, pilot-scale tests may be required since information necessary to conduct full-scale tests is either limited or nonexistent.

A pilot-scale test, as compared to a bench-scale test, is intended to more accurately simulate the operations of a full-scale process. However, pilot-scale tests require significant time and can be quite costly. Therefore, the need for pilot-scale testing must be determined by comparing the potential for improved performance or savings in time or money during remedy implementation against the additional time and expense needed for the test. Pilot-scale testing is often appropriate for innovative technologies, and such testing will be considered if it offers the potential for more permanent waste treatment or destruction, or the potential for significant savings in time or money required for a remedy to achieve remedial action objectives.

Prior to the initiation of any pilot-scale testing, the following information, in addition to the items mentioned above with regard to bench-scale testing, will be collected or developed:

- Unit-specific information impacting test requirements (waste characteristics, facility characteristics, availability of services and equipment)
- Waste requirements for testing (volumes, need for any pretreatment, handling, transport, and disposal)
- Specific data requirements for technologies to be tested.

Recommended formats for bench-scale and pilot-scale treatability investigation work plans, along with further details on the process, can be found in EPA draft RI/FS guidance (EPA 1988).

2.0 TREATABILITY INVESTIGATION IMPLEMENTATION

This portion of the Phase 2 RI is reserved for the actual implementation of any treatability investigation or additional operable unit characterization activities deemed necessary. However, every effort will be made to attempt to gather all operable unit characterization data under the Phase 1 RI. The results of this task will be integrated into the preliminary site characterization summary (Phase 1 RI report) to create the final RI report.

3.0 REMEDIAL INVESTIGATION REPORT

The treatability investigation results will describe the testing that was performed, the results of the tests, and an interpretation of how the results would affect the evaluation of the remedial alternatives considered for the operable unit. The report will contain a discussion of the effectiveness of the treatment technology for the wastes onsite and will contain an evaluation of how test results affect treatment costs developed during the detailed analysis of alternatives. These results will be combined with the operable unit characterization results, including the results of any further activities carried out under the Phase 2 RI, and published as the final report documenting all RI activities for the 1100-EM-1 RI/FS project.

4.0 REFERENCE

EPA, 1988, *Draft Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, (OSWER Directive 9355.3-01, March 1988), U.S. Environmental Protection Agency, Washington, D.C.

APPENDIX F

NORTH RICHLAND WELL FIELD

APPENDIX F

NORTH RICHLAND WELL FIELD

1.0 INTRODUCTION

The north Richland well field and groundwater recharge basin system is a significant component of the City of Richland water supply system. This well field and basin system are located in north Richland (Figure F-1) and consist of eleven pumping wells, three groundwater recharge basins, and a settling pond. Table F-1 presents available well construction information for each well. The well field is located approximately 1/2 mi west of the Columbia River, on the edge of the Columbia River flood plain, with ground surface elevations ranging from about 360 ft on the side closest to the Columbia River (east) and about 400 ft on the west side.

Table F-1. Well Construction Information for the North Richland Well Field.

Well designation	Hanford well number[a]	Casing elevation (ft)	Diameter (in.)	Drill depth (ft)	Perforated interval depth (ft)	Drill date
3000-A	11-40-15	395.93	20	88	47 to 81	1948
3000-B	11-40-16B	392.82	20	90	47 to 84	1948
3000-C	11-39-16D	371.17	20	64	32 to 62	1948
3000-D	11-39-16C	385.77	20	75	41 to 71	1948
3000-D-5	30-42-16	407.63	12	134	55 to 125	1944
3000-E	11-39-16A	368.82	17	62	22 to 58	1948
3000-H	11-40-16C	381.00	20	55	25 to 50	
3000-J	11-39-15	393.00	20	71	44 to 69	1952
3000-K	11-38-16		20	59	15 to 50	1952
3000-L	11-39-16E	398.00	20	83	56 to 81	1953
3000-N	11-37-16	363.40	20	56	24 to 40	1961

[a]Hanford well number: 11 indicates 1100 Area, 30 indicates 3000 Area.

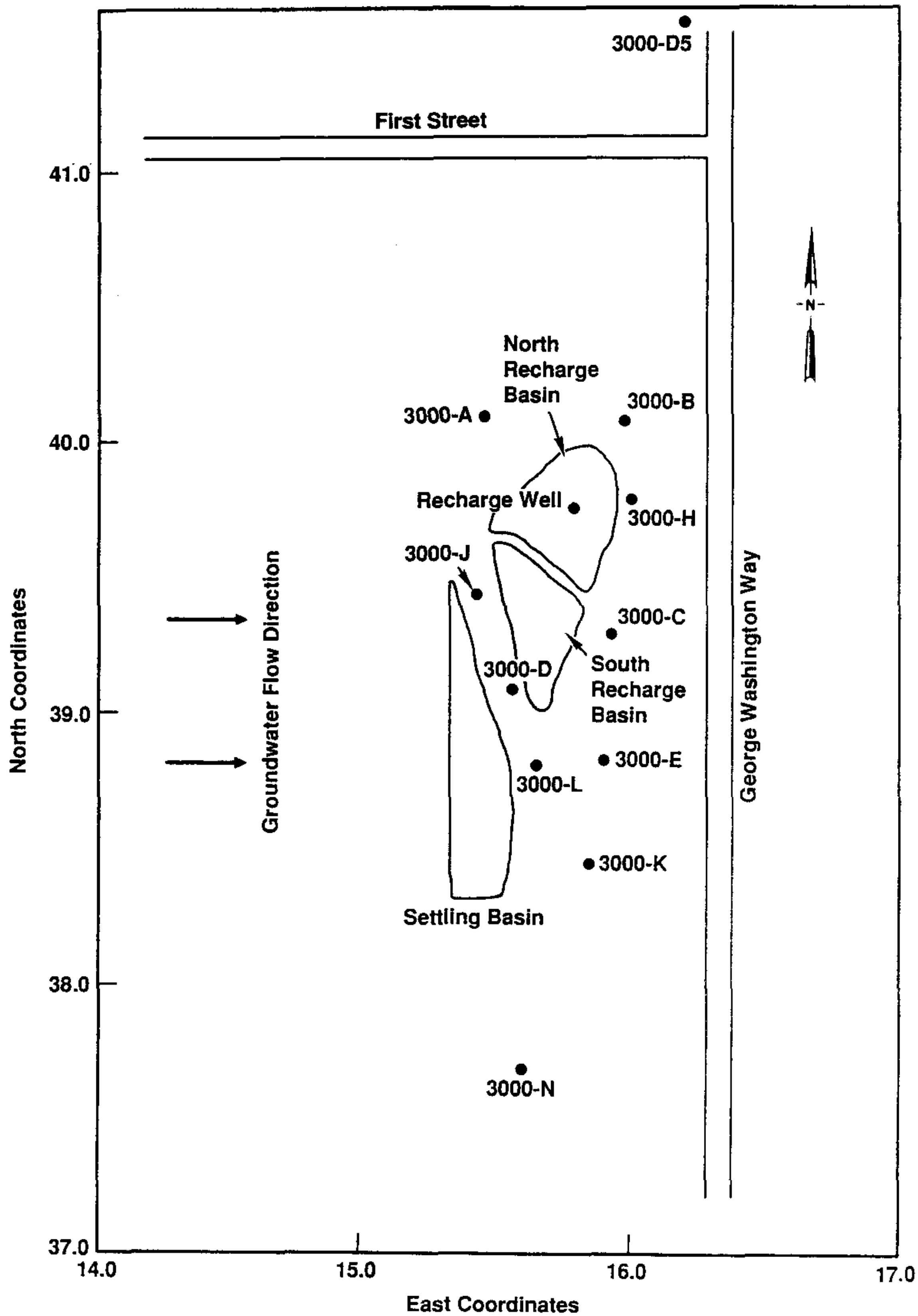

Figure F-1. Location and Layout of North Richland Well Field and Recharge Basins.

2.0 HYDROGEOLOGY

Sediments encountered in the wells of the north Richland well field are predominantly unconsolidated sands and gravels with a minor amount of silt. From the ground surface downward the sediments include the following units:

- Pasco gravels--Unconsolidated sands and gravels of very high permeability to a depth of 15 to 55 ft (elevation 345 ft). This unit is glaciofluvial in origin and is often informally called the Hanford formation

- Ringold Formation--Unconsolidated to sometimes partially consolidated sands, gravels, and silt or clay, having a thickness of approximately 145 ft. The formation is generally less permeable than overlying glaciofluvial deposits. The lowermost 20 to 40 ft are composed of silt or clay. The remainder of the formation is predominantly sand and gravel. A silt layer at 90 to 50 ft of drill depth (approximately 310 ft elevation) may form the base of the unconfined aquifer, but its continuity is not well established. Existing data suggest that the layer is fairly continuous in the 1100 Area and the north Richland well field; however, it is not continuous in the 300 Area. When the upper silt layer is not present, the bottom of the unconfined aquifer is the lower silt or clay layer at the base of the Ringold Formation (approximately 220 to 240 ft elevation or 180 to 120 ft of drill depth).

Groundwater flow direction in the unconfined aquifer of the region is from the west to the east with the Yakima River as the dominant recharge source and the Columbia River as the discharge location. The general gradient in the area is approximately 8 to 10 ft/mi. The water table roughly follows the Pasco gravels-Ringold Formation contact. The 1100 Area, north Richland well field, and 300 Area are near the upper reaches of McNary Pool, created by McNary Dam, which is approximately 50 river miles downstream. McNary Pool has an average stage of approximately 340 ft elevation. Well pumping and the artificial recharge taking place in the well field locally alter regional groundwater flow patterns of the unconfined aquifer.

Two constant rate pumping tests were performed in the north Richland well field on the unconfined aquifer in October 1987 (ICF 1987). The first test was performed on well 3000-J at 300 gal/min for 24 h. After 24 h of pumping, no drawdown was observed in the observation wells or the pumped well. For the second pumping test, well 3000-H was used as the pumped well, and well 3000-B was used as the monitoring well. Well 3000-H was pumped at 1,340 gal/min for 98 h. A maximum drawdown of 4.0 ft was observed within 1 h of the start of the test and remained constant for the remainder of the test. The maximum drawndown of 0.66 ft in monitoring well 3000-B occurred after 24 h and remained constant throughout the rest of the test. Twenty-four hours after the pumping stopped, the water level in well 3000-H had recovered to within 1 ft of the starting level, and well 3000-B, the monitoring well, was still at 0.66 ft. Transmissivity was calculated to be 644,600 (gal/d)/ft, and the storage coefficient (specific yield) was calculated to be 0.11.

3.0 HISTORICAL OPERATIONS

The well field and recharge basin system have been used since 1948. Since 1963 the well field has been used to supplement the Richland water supply during peak demand and the annual shutdown of the Richland water filtration plant (HDR 1988). The well field produces a daily average of 0.5 to 7.8 Mgal of water (ICF 1987) from the unconfined aquifer for 10 to 12 mo/yr with the highest production in the summer months.

The unconfined aquifer at the well field is recharged through a system of settling and recharge basins centrally located in the well field. Water from the Columbia River is pumped from the city's intake structure near the filtration plant to the settling basin through a 27-in. line. The recharge water enters the south end of the settling basin before discharging through a concrete weir and flow divider into the two recharge basins. Recharge flows into this system range from zero during low production periods to as high as 16.0 Mgal/d during July. The monthly totals for recharge and production for the years 1985 through 1987 are shown in Figure F-2.

4.0 REFERENCES

HDR, 1988, *Water Filtration Plant and North Richland Well Field Evaluation*, Final Report prepared by HDR Engineering for the City of Richland, Richland, Washington.

ICF, 1987, *Geohydrologic Study of North Richland Well Field and Groundwater Recharge Basins*, principal contributors C. W. Miller, J. G. Bush, and F. W. Bond, prepared by ICF Northwest for the City of Richland, Richland, Washington.

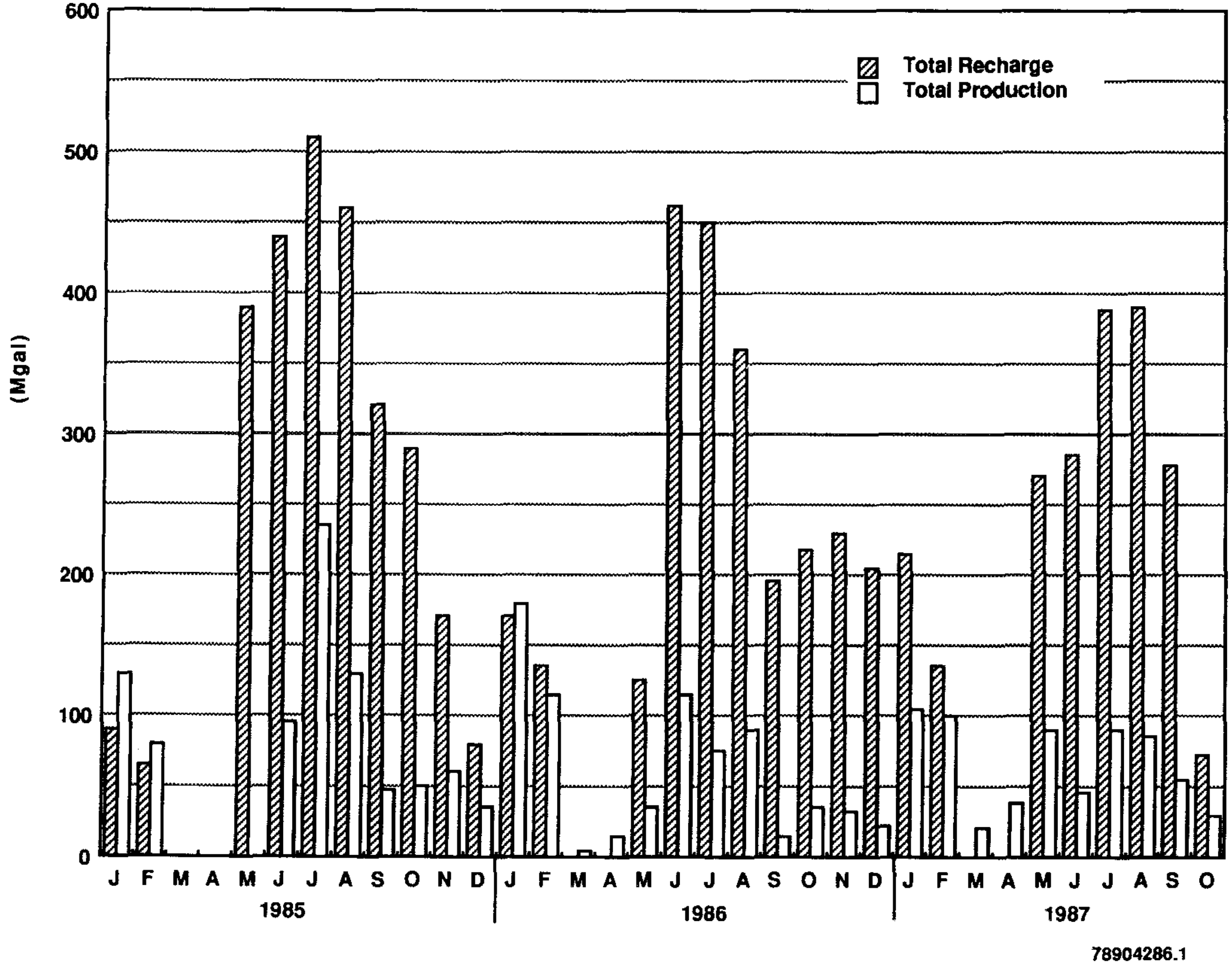

Figure F-2. Total Recharge and Production for North Richland Well Field 1985 - 1987.